2-28-1835

In Senate of the United States. Report from The Secretary of War, with a report of the mineralogical and geological investigations made by G. W. Featherstonhaugh.

IN SENATE OF THE UNITED STATES.

REPORT

FROM

THE SECRETARY OF WAR,

WITH

A Report of the Mineralogical and Geological Investigations made by G. W. Featherstonhaugh.

February 28, 1835.
Read.

March 3, 1835.
Ordered to be printed; and that 1000 additional copies be furnished, for the use of the Senate.

War Department, *February* 28, 1835.

Sir: In obedience to a resolution of the Senate of the 14th instant, I have the honor to transmit, herewith, the report of Mr. G. W. Featherstonhaugh, who was charged with a "mineralogical and geological investigation," under an act of the last session of Congress.

Very respectfully, your most obedient servant,

LEW. CASS.

Hon. Martin Van Buren,
President of the Senate.

Topographical Bureau,
February 28, 1835.

Sir: I have the honor to lay before you a copy of the report of G. W. Featherstonhaugh, Esq., called for by a resolution of the Senate of the 14th instant.

Very respectfully, sir,
Your obedient servant,
JOHN J. ABERT,
Lieut. Col. Top. Engineers.

Hon. Lewis Cass,
Secretary of War.

WASHINGTON CITY, *February* 17, 1835.

Lieut. Col. J. J. ABERT,
U. S. Topographical Engineers.

SIR: In obedience to your instructions, dated July 12, 1834, to repair to some point on the northern boundary of the Territory of Arkansas, and personally inspect the mineral and geological character of the highlands and water sheds where the public lands are situated, of that elevated country lying between the Missouri river and Red river, known under the designation of the Ozark mountains, and limiting my return to the seat of Government, to make my report, to the 1st day of February, 1835, I have the honor to state:

That, having executed those instructions, I reached the city of Washington on the evening of the 31st of January, 1835, having accomplished a distance of four thousand six hundred miles during my journey, of which upwards of three thousand miles were effected by land.

Before I enter upon the details of this report, I beg to observe that, aware of my being directed in my instructions to the examination of the public lands exclusively, if, for the purpose of illustration, I should apply the geological information I possess of other portions of the structure of this continent, it will be because I am invited in my instructions to do so, and from which I beg to quote the following passage:

"Although, by these instructions, your investigations are limited to the Territory of Arkansas and the adjacent public lands, it is nevertheless desirable that, in the report to be made by you on your return to this city, whatever geological information you may possess, which can be usefully applied to the illustration of the investigations you are about to make, and which may aid in developing the resources of the countries you are directed to examine, and their geological connexion elsewhere, should be fully stated for the information of the Government."

Geology being altogether a science of observation, and the cautious spirit of the present times giving no weight to any opinions which do not follow the practical examination of physical phenomena, I venture to pledge myself that this report will be in accordance with a rigorous regard to this salutary temper of the age; that all the facts contained in it are the result of my own personal examinations, and that the opinions I shall have occasion to advance, respecting the geological structure of those parts of the United States described herein, appear to me to be plain deductions from a long series of personal investigations effected in Europe and on this continent.

It is also from a sincere desire to make this report as permanently instructive as possible, that I have thought it advisable to prefix to the details of my late observations a brief account of those leading principles of modern geology which are the result of the labors of some of the most eminent men in Great Britain, France, and Germany—men whose names obtain the willing confidence of Europe and America. I should think myself greatly wanting in that earnest desire to make my labors extensively useful, with which a man, honored as I have been in the selection to perform this important duty, ought to be inspired, if I were not to endeavor to make this report as transparent to the intelligence of all who may read it as the nature of the subject may admit of; and this I could not do, in the present state of geological knowledge in this country, if I were simply to relate what I have

seen, and then come to general conclusions, without illustrating the subject by such an exhibition of the principles of the science, and by such an application of legitimate reasoning from them, as would bring out the facts I have observed in prominent relation with the general mineral structure of the globe; with the design, not only of satisfying those least conversant with the science of geology of the great usefulness and beauty of the science, but of enabling them to form a competent judgment as to the accuracy of my own labors, and the degree of confidence due to my own opinions. Had my report been addressed only to the scientific few, I am aware that this would have been superfluous; but as the appointment I have been honored with was for the benefit of the many, so I must ask to be permitted to consider myself as still acting in that relation to the country.

Practical geology can be conversant only with the crust of the globe, being that portion of it which is comprehended between the lowest observed depths of any mines, and the greatest elevation of any mountains. It is within these limits alone that observations can be made, if we except examinations of those mineral substances which have, at various periods, been ejected, in a state of igneous fusion, by volcanic action, from the more central parts of the earth, such as the lavas occasionally proceeding from the active volcanoes of our own times. But this superficial portion of the globe, which may be estimated at a depth of about seven miles, is comparatively insignificant in its proportion to the mean radius of the earth, which may be estimated at about three thousand nine hundred and fifty-five miles: still it is sufficiently comprehensive for the whole economy of nature, both external and subterranean; and the immense disproportion between it and what lies beneath it, instead of leaving an impression of insignificance upon our minds, leads them to the contemplation of the immeasurable power of that expansive agency which we know, from the evidence of volcanic action, has, even in our own times, a modifying effect upon the superficial part of the globe, and which it is not unreasonable to believe may have been, in all time, in a constant state of exertion in that immense and impenetrable space comprehended within the diameter of the earth. Knowing, as we do, that the crust of the earth has been constantly modified by subterranean action, and believing, as a great majority of modern geologists do, that all its mineral characters are most rationally accounted for by the direct and indirect agency of such a power, we cannot avert ourselves from the consideration of so magnificent a provision for natural operations; and hence men have ceased to attempt explanations of the economy of the earth's structure, by an hypothesis of entire aqueous action, altogether imaginative, but now happily expired, together with the authority of teachers who embarrassed the progress of human knowledge.

But we are not to regard the radial space as a mere vacancy where igneous action is exerted, but as a field where it acts upon matter in states and conditions of which perhaps the scientific chemist has but a faint conception; and we are taught, upon the authority of eminent philosophers, that the density of the interior is much greater than that of the crust. It will be perceived, from this mode of reasoning, that such a radial space, acting under such conditions, could not but produce results equivalent to the grandeur of its power; and hence it is not surprising that geologists should refer the origin and actual state of what is called the crust of the earth to its direct and indirect action.

Some of the modes by which such a force might act, may be expressed in a few words. If we consider the opinions of some distinguished philoso-

phers, who believe that our earth is an ancient igneous body, which has for long periods been cooling, we certainly find a relation between such a process and the lowest rocks in the geological series, usually called primary; these rocks being all considered, by the most eminent geologists and chemists, to be the result of mineral matter cooled down from a state of igneous fusion. But those rocks, which are found at the lowest points where geological examinations can be made, constitute also the loftiest summits of mountains—a seeming paradox to those who have not turned their attention to this subject, deserving of explanation here.

The mean height of the continents of our globe, which, with its islands, stand, in relation to that portion of the surface they occupy comparatively to the sea, as about one to three, is thought to be near two miles; whilst the sea is considered to have about an equivalent mean depth. If, therefore, at any period in the history of our planet, the mineral matter constituting the dry land has been distributed beneath the waters of the sea, an arrangement, as we perceive, very possible, and apparently very probable, the planet would then have been entirely covered by water. In such a state of things we have no cause to which to refer the origin of our continents and islands, save the expansive subterranean force before alluded to, which could raise them from the bottom of the ocean and above its level. It is most satisfactory to reflect, that, without any reference to this theory, the progress of geological investigation has led the leading geologists in Europe to the conclusion, that not only continents have been in this manner raised, but that all the important chains of mountains have in like manner been protruded from below; and in many instances the proofs are obvious, of the dislocation of the stratifications through which they have burst, to rear themselves to the lofty heights they have obtained. It will be apparent to every one that successive upliftings of mineral matter would displace an equivalent cubic quantity of water, and that in proportion to the amount of mineral matter protruded would be, not only a corresponding agitation of the adjacent ocean and formation of currents, but an abrasion and partial destruction of pre-existing lands, the ruins of which, often extremely broken down and comminuted, would again, at a period of repose, be deposited at the bottom of the ocean, to be again, at some future period, elevated above its level.

In these direct and indirect operations of the expansive power beneath the crust of the globe, have been perceived the happy means of compromising the conflicting views entertained respecting many important geological phenomena; since both the results of igneous action and aqueous deposition can be referred to the same cause, as well as the paradoxical appearance of rocks of the same class, of undisputed igneous origin, which have been observed at the lowest depths of the crusts of the globe, and at its most elevated summits; these latter being evidently thrust up from below.

The application of these views of subterranean action, which are not sketched here from a theoretical predilection, will be found highly important in relation to the structure and continuity of metallic veins. The mineral resources of the United States, as will be asserted in this report, are commensurate with the grandeur of its other physical features, whilst there is still much hesitation about the introduction of systematic mining. It was a prevailing opinion, whilst the Wernerian theory obtained, that metallic veins were filled in by deposites from above; and it has been extensively believed in this country that the galena, or sulphuret of lead, found in the State

of Missouri, was a mere superficial deposite. Opinions of this kind operate powerfully to restrain capitalists from giving their confidence to mining undertakings in an efficient manner; they are afraid to invest their means beyond an amount necessary to conduct partial diggings and excavations near the surface; whereas, if they were satisfied of the reasonableness of the opinion that metallic veins have their origin from below; that the veins, which have repaid them moderately near the surface, are generally considered to improve at a depth of five hundred feet; that they have been successfully followed up and cut out at three times that depth; and that we have no practical evidence of their want of continuity to infinitely greater depths, they would not hesitate to sink their shafts and establish their works upon a scale of magnitude corresponding with their confidence, and producing results favorable to national industry and to their own just expectations.

But laying aside this branch of the subject at present, and reverting to the supposed igneous central action of this planet, it would seem to invite an important consideration, whether, if this action be general, the results produced by it may not, with some modifications, be expected to present a close affinity in their general character throughout the globe.

It is not to be denied that the European geologists have examined the structure of a great portion of their eastern continent with unrivalled perseverance and energy, and have brought to the consideration of its phenomena all the acumen of which mineralogical and chemical learning is almost susceptible; for some time past their most eminent men have called for geological investigations of this western continent, as most important desiderata in physical science. It has been deemed by them necessary, for the further advancement of the science, to have a comparison instituted between the geological formations of this western world and their own portion of the globe, in order to determine how far the phenomena common to both belong to causes which have been cotemporaneous, or of the same class; whether the principles which have determined the structure of the one have been the governing cause in the other, and to what causes any discrepancy may be assigned.

This inquiry is of deep interest to us in this country, not simply as one which leads us into a field of philosophical research highly favorable to enlargement of the intellectual powers, but as pregnant with utility in relation to the business pursuits of life, enabling us to apply the fruits of their long and rich experience to the immediate development of the mineral resources of this country, and returning to them some measure, at least, of information for those inestimable labors which have preceded our own investigations. Strongly impressed with these views, I have constantly endeavored to make them auxiliar to my late examinations. In concisely submitting the arrangement of rocks, as it is declared to exist, and as I have observed it in Europe, with a comparative view of the principal formations in those parts of the United States I have lately visited, I shall not advert to the numerous divisions into which the whole known series of rocks has at various times been thrown. The voluminous literature belonging to modern geology has produced numerous classifications from the geologists* of France and Great Britain, all of which, however useful in the study of the science, appear destined to fluctuation and change in its progress, like the graceful and waving

* Al. Brogniart, a rare example of learning and genius in France; Coneybeare and De la Beche, two of the most eminent geologists in Great Britain.

lines formed by the rippling on the sea beach, which are modified or obliterated by every new breeze impressing the coming tide. From circumstances no longer subject to control, the science and letters of Great Britain will forever become an inherent part of the intellectual power of this country. The old and simple divisions of primitive transition, secondary, and tertiary, to which the English geologists so long adhered, and which have been adopted in this country from their elementary works, are, it is true, not free from objections, but they are convenient and familiar here; and since all classifications are imperfect and subject to change, I have thought it best, where classification must be resorted to for purposes of illustration, to use that which is best known, with no disposition, however, to assign any value to it beyond the facility it gives me of making myself understood.

The result of the observations of the European geologists, up to the present time, has shown that the inferior part of the whole geological series of rocks is distinguished by characters which do not belong to the superior portion.

It is to a great degree unstratified.

It has a confused, irreguiar, crystalline, granular structure, composed of quartz, mica, and felspar, from whence the lowest portion of it has received the designation of granite.

In some instances it is beautifully studded with regular crystals of felspar, and is then called porphyritic granite.

It contains metalliferous veins, bearing copper, iron, and the precious metals.

It contains, also, granite and other veins, which have obviously passed through it subsequent to its original formation, since we occasionally see that at the passage of these veins the rock has been dislocated from its continuity, from whence it may be inferred that the passage was accompanied by a force of great violence.

From a careful study of all the circumstances attending them, it is now the general opinion that rocks of this class are the result of igneous fusion.

Other members of this inferior portion of the geological series, though partaking largely of the preceding characters of the granitic rocks, are very different in their external appearance. The rocks called gneiss, which are often found superincumbent on the granite, have a more regular arrangement of the planes of the mica contained in them, which give them frequently an appearance of stratification, resembling that produced by deposition from water; how far this may be owing to a distribution of the plates of its mica paral lel to its strata, and which appears to be the immediate cause of its fissility, cannot now be asserted: this, however, is true, that the granitic rocks and the gneiss pass into each other so completely, that I have frequently on this continent taken specimens of the gneiss, especially from near Richmond, in Virginia, which, if placed in a cabinet, any mineralogist would pronounce a true granite; and certainly nothing is more common here than to observe broad veins of true granite passing into the beds of gneiss, and, indeed, the granite alternating with the gneiss. There is another important rock, known under the name of mica slate, which is usually destitute of both felspar and hornblende. The gneiss, which contains more mica than hornblende, appears to pass into this, and the difference between them to be owing to the absence of some of its constituents.

The mica slate itself passes into talcose slate, talc being substituted for mica. This last is a mineral formation, in which the auriferous veins of

the United States are found: in some parts of the country, the veins pass through a field of talcose slate several miles in breadth; in others, the veins are sheathed only, as it were, in the talcose slate, and pass through a field of elvan and granitic rocks.

The other most important members of this inferior portion of the geological series, commonly called primitive rocks, are statuary limestone or white marble, serpentine, greenstone, quartz rock, the varieties of hornblende rocks and slates, and clay slate.

The rocks hitherto enumerated have one common character; they contain no organic remains, and may, therefore, properly be called inorganic, in relation to animal and vegetable bodies.

All these rocks, so different from each other in their external appearance, have yet, with the exception of the statuary limestone, no greater difference than is constituted by the presence or absence of some mineral constituent, or the difference of proportions. Some of the most important members, such as granite and gneiss, contain silex as a constant constituent, others contain magnesia, and some hornblende; but a serious study of the whole, and of the relation in which they stand to all other rocks, impresses a strong opinion upon us that they owe their origin to the same cause, and that they have all, at some period, been either ejected from central depths by the expansive power generated there, or that they have been great intumescing masses, which, on cooling, have resolved themselves into various stages of crystallization, and that their varying products have been brought into fusion or solution from distinct central localities, some of the differences between them having been occasioned by a chemical action, more easily imagined by us than described.

These considerations point to a state of things totally different from any thing which obtains in our own days. Primitive rocks are found in all those parts of the earth which have been examined, and there is every reason to believe that, together with the indurated lavas which in our own times we see ejected by volcanic forces, they form the solid basis of the crust of the globe. A great portion of this basis is now covered to great depths by the sedimentary rocks which have been subsequently deposited by water, but vast tracts of inhabited country are constituted by these primitive rocks. In the United States, they occupy the surface from Maine to Columbus in Georgia, on the Chattahoochie, and still further, to Wetumpka, on the Alabama. Boston, New York, Philadelphia, Baltimore, Washington, Richmond, and Columbia, in South Carolina, are either built upon it, or are separated from it by deposites of an insignificant depth. Yet the whole of this mighty basis was once in a state of igneous fusion, and under circumstances which prevent the possibility of our expecting to find organic bodies cotemporaneously existing in it, since it was a state of things inconsistent with the existence of organic matter.

We delight to repose for a moment in the contemplation of such grand and beautiful arrangements established by Providence for the wellbeing of his creatures. Mountains and continents raised from the deep to heights which afford salubrity and security, and where nature can offer the most varied and attractive residence to both man and the animals; and the crust of the earth, prolific in minerals, with all useful and precious metals, in the proper proportions for his immediate wants. Nor has the laboratory of nature yet ceased its action. The granitic rocks, which we find injected

into their cognate masses, do not flow from recent volcanoes, it is true; but the trap rocks, which are but modifications of the primitive rocks, have been found, both in Europe and in this country, injected into the primitive, and are still poured out of modern volcanoes in the form of lava. Even modifications of the granitic rocks are supposed to have been found overlaying the fossiliferous rocks, clearly establishing their intrusive character. Some inhabited parts of the globe, too, are supposed to be in an actual state of gradual elevation.

With all these concurring proofs of igneous action, and of an immeasurable expansive power operating beneath the crust of the earth, I should deem myself more obnoxious to the charge of having suppressed them, in the present state of geological knowledge in this country, than to that of having been indiscreet in assigning them a place in an official document, on the ground of their theoretical character.* A pure hypothesis, raised upon conjecture, and not sustained by admitted facts, is always to be avoided; but I should hesitate to render myself liable to the charge of theoretical tendency, in a light sense of that word, if I was conscious of entertaining conclusions other than those to which the mind is irresistibly brought by concurring facts, upon which the judgment willingly reposes.

Wherever the primitive rocks in question occur in transatlantic countries, they are found under circumstances which clearly prove that they owe their existence to the same general chemical laws, and have been produced in the same manner. They have been found in Asia, Africa, and in various portions, especially the northern ones of Europe. They are not only found almost identically the same, but their various members are superimposed upon each other in the same order. I have seen specimens of porphyritic granite from Shapfell, in England, from Ceylon, from China, from Russia, and the Alps, which would be indistinguishable from that which forms the bed of the bituminous coal field of Chesterfield, Virginia, the broad belts which run at the foot of the Blue Ridge, and parallel to it, and some which I have observed in Georgia. The structure of the tin and copper districts in England, as far as the nature and direction of veins is concerned, would lead a student exactly to the same conclusions, in regard to their origin, and the utility to be derived from a knowledge of it, as if he had been studying the gold and copper veins of the United States. The structure of the auriferous rocks in Russia and Brazil, as it has been described to me, is precisely what we find it to be in the gold region of the United States. Tin has not yet been found in the primitive rocks of this country in the profusion it is found in Cornwall; neither has gold been found in Great Britain as it is found in the United States, containing very productive veins, which have been examined for a distance of more than eight hundred miles to the south from the Potomac river, and showing themselves occasionally in an auriferous character, at an equal distance to the north. But gold has been found in small quantities in Great Britain, and tin, of which I possess some traces, has been found in the United States. In the Ural mountains of Nor-

* Of the source and cause of this great central power, we can assert nothing with precision. Philosophers account variously for it: but such is the state of knowledge, that it appears more unphilosophical to deny its existence because we are not agreed upon an explanation, than it is to assert it. The same philosophers who are sceptics on this subject do not deny the sun to be the source of solar heat; yet, an eminent person has lately asked, from a conspicuous official chair, why "the heat has not passed away by conduction; and, if it has passed away, by what other heat it has been replaced?" At present, it seems to be expedient to be content with such causes as explain known effects.

thern Russia gold is a productive metal, and platina has been found in considerable quantities. Platina has at length been found in the United States; a specimen of it has lately come into my possession; and it is become extremely probable that the associate precious minerals, such as the diamond, the topaz, &c., will very soon be produced.

It may, therefore, be safely asserted, that this great non-fossiliferous division of the known rocks of the geological series, and to which an igneous origin has been attributed, is, in all the circumstances connected with its crystallization, its metalliferous character, its constituency, and the superposition of its different members, essentially the same in North America and in the other parts of the globe where it has been observed. It appearing unnecessary to seek for distinct causes to phenomena which are mere repetitions of each other, the accordance between this branch of the geological series, as to unity of cause, may be considered probable in both hemispheres.

The other great division of the geological series of rocks, and which, from its being the depository of the remains of those organic bodies which preceded the present order of things, may be called the organic division, has been subdivided into three divisions: transition, secondary, and tertiary. The rocks comprehended in the transition class received that name in the early days of the science; because in these was discovered an apparent transition from inorganic to organic matter, and from a chemical to a mechanical origin of rocks. And, in truth, it is in those argillaceous slaty masses, and beds of roofing slate, which immediately succeed to the primitive rocks, that we find the first vestiges of animal and vegetable existences, but extremely rare when compared with the profusion in which they are found in the superior rocks. Yet the fossils found imbedded in them are not to be considered as representatives of the first class of animal bodies which came into existence. The masses in which they are found imbedded being all formed under water, we must of course look to find no animal remains but of such animals as were fitted to live in that element, viz., fishes and shell fish, and crustaceous animals. These having some solid parts, liable to be enclosed with an argillaceous covering, might leave some traces of their existence, and which a few of the two last enumerated have done. The scarcity of these is in accordance with the mineral state of the earth at the period when the rocks were formed in which they are enclosed. The solid parts of these animals, when living, are formed of lime, which, from the small proportion in which it exists amongst the other primitive masses, was not, as appears consistent with the general design, to be produced in the profusion it subsequently was when animal existences, to which it was indispensable, were to be brought forward in great numbers.

The general deposites of calcareous matter on the globe have been, by some persons, attributed to the exuviæ of animals, without stopping to inquire whence those animals derived the solid parts they have left behind them. As we know not that animals have the power of forming lime from other mineral elements, we are compelled to suppose that the calcareous matter forming their osseous structure, their testaceous and crustaceous coverings, preceded them. In considering the primitive rocks, we perceive that forces of great power, and unknown to modern times, have been in action in the earlier periods of the planet—forces which even now continue occasionally to act, though feebly and rarely. As to the manner in which the statuary limestones were produced, there is much ambiguity. If lime,

as we know, can be fused under pressure, it can be rapidly ejected when in a state of fusion; but we have no recent instances of limestone being thus formed. We know, however, that mineral springs, both thermal and cold, deposite carbonate of lime in great quantities, as they come in contact with the atmosphere. The prodigious deposites of this character from a cold mineral water in the Sweet Springs valley, in Virginia, which presents one of the most rare geological phenomena in christendom, and the no less interesting travertino deposited by the hot springs of the Washita, in Arkansas, both of which localities I visited this last year, and similar phenomena in various parts of the world, render it quite possible that some extraneous calcareous deposites, lying amidst the primitive rocks, have come from the central parts of the earth in a state of aqueous solution, that has been subsequently evaporated. With springs of such a character in action, the animals of those times could be at no loss for calcareous matter in favored localities; and, in that greater portion of the aqueous surface where lime was wanting, we can readily believe that the creative power might give a benevolent existence to countless myriads of those gelatinous animals which fill some tropical seas in our own days, and which, having no solid parts, have left no vestige of their existence behind them.

It is, I think, to be regretted that the term transition has been applied to any other rocks than the argillaceous masses in question; but the connexion between these and the grauwacke slates which succeed them, and that between these last and succeeding deposites higher in the geological series even than the coal measures, has induced some geologists to consider all the members of this connexion as belonging to one natural group. Such a group would include the slates in question, the grauwacke, the old red sandstone, the millstone grit, the carboniferous limestone, the coal measures, and some rocks of an ambiguous character resting upon them in particular localities. By some persons, however, and perhaps by the greater number of the older English geologists, most of the last enumerated formations are placed in the class called secondary. In the north of England the grauwacke is found lying at a great inclination, and upset on its edges, with conglomerate or old red sandstone lying unconformably upon them, showing that this last, not being affected by the movement which had thrown the grauwacke out of its horizontality, or having been deposited since that movement, was not, in the estimation of some persons, to be classed in the same division with the grauwacke. By these the grauwacke was considered the limit of the transition series; but in countries where the old red sandstone and the grauwacke laid conformably on each other, the argument was equally strong for arranging the superincumbent formation in the same series with the inferior one; and those last enumerated rocks being both found in the United States upset on their edges at very high inclinations, no ground whatever is presented here for considering them as appertaining to distinct divisions, whilst a real connexion is shown both by their chemical and mechanical structure, as well as their organic remains.

The principal characteristic of this series of rocks, and which has already given a name to one of its most important members, is fossil coal; the most productive beds of which have been invariably found in this series, and important seams in all the members of it. It is a subject of deep and lasting interest to this country, to possess an accurate knowledge of the localities and extent of its coal fields, upon which the country must ultimately be thrown, as Great Britain has long been, for fuel for domestic

purposes, and for the support of her manufactories. It may be asserted, without exaggeration, that from her coal mines have proceeded the wealth and power that have long given her so conspicuous an influence in the world. It must always be regarded as a remarkable circumstance, that immediately subsequent to the arrangement of metallic veins, a series of carboniferous rocks should have been produced, by the efficient aid of which the metals could be extracted from them: in these same carboniferous rocks, too, not only is iron ore found in great abundance, but limestone to flux it, as if some provident hand had been arranging every thing for the industrious human family that was to have dominion over the world.

In all essential circumstances, the features which mark the structure of the coal-bearing series of rocks in Europe are found here. In the grauwacke we have beds of limestone, derived, for aught we know to the contrary, like the statuary limestone in the primitive series, from solutions ejected from below, alternating with schistose and sandy beds of probable mechanical origin. In these limestone beds we occasionally find, as in Europe, increased numbers of animal remains, and cognate in their relations, such as the flustra, the trilobites, &c., on the calcareous plates from Dudley, which are often identical with those of the Alleghany ridges.

In the lower parts of this series, in Europe, are found those non-bituminous coals now generally known here under the name of anthracite, and in this country we find the same carbonaceous matter distributed through the whole system of Alleghany ridges to the most western counties of Virginia, where the inclined rocks begin to give way to the horizontal formations of the Cumberland range of mountains. Higher up in the series, and reposing upon the vast deposites—in this country immense—of carboniferous limestone, where that mineral is not replaced by more complex deposites, we find, in Europe, the great productive beds of bituminous coal, exactly as they are found in some parts of this country, lying amidst shales and sandstones, often of a friable structure, and abounding in mica. The fossil plants, too, are nearly related in both countries, and some identical. It is true the coal in some instances in Europe, as at St. Etienne, in France, is found resting upon the naked granite, which is exactly the case with the coal measures of Chesterfield, Virginia; this lies in troughs of granite, the edges of which crop out above ground, showing the exact limit, in some instances, of the coal field. Nor is it to be supposed that, because intrusive rocks of a granitic character have appeared subsequent to fossiliferous rocks, the base of these coal measures has thus been formed, and cotemporaneously with the carboniferous deposites which repose on them, for the Chesterfield granite is a well defined and beautiful porphyritic granite, with its red crystals of felspar, precisely resembling that of Shapfell, in England, and forms part of that extensive granite formation which looks at the Atlantic coast from the east flanks of the Blue Ridge, and which I have traced far into Alabama.

Nor is that extraordinary coincidence in both hemispheres, in the state of the beds of the carboniferous limestone, to be overlooked. Some of them, teeming with the imbedded exuviæ of animals; others conspicuous for the plates and irregular masses of chert, resembling the flint as it is seen in the chalk beds of Europe; whilst both alternate with beds of compact

Those who have seen the enchrinital and other beds of the European car-

boniferous series, may see the same thing repeated in various parts of this country; in the western parts of the State of New York; at the Helderbergh mountains; conspicuously in Tennessee, in Kentucky, and the State of Missouri. Here, in some instances, the rocks appear to be composed entirely of organic remains, whilst others seem to have been deposited so rapidly as to have given no time for their production. It is at this period, however, and, amidst this profusion of calcareous matter, that such immense numbers of testaceous animals of the same kinds have existed in both hemispheres.*

It is deserving the attention of those eminent geologists who have adhered to the opinion that all carbonaceous matter has a vegetable origin, that many coal deposites in this country appear to have been effected under circumstances which do not favor that opinion. In the lower slates in the State of New York, and not far from Poughkeepsie, are veins, at a high inclination, of non-bituminous coal, from one to more inches in breadth. It will hardly be pretended that these have a vegetable origin. In Worcester, in Massachusetts, and in Rhode Island, it is associated with carburet of iron, and exists under circumstances that, notwithstanding the accompanying vegetation on the shales, which, nevertheless, does not form an integrant part of the coal, by no means points to a vegetable origin. There are also reasons to be adduced which may shake our confidence in the vegetable origin of the non-bituminous coals of the grauwacke series of the Alleghany ridges.

In examining the structure of the transition series of rocks, we perceive that it partakes largely of a mixed character, both chemical and mechanical. Many circumstances, presenting themselves under various aspects in different and distant localities, point to a direct central origin for the limestone beds, and for those siliceous solutions which have frequently changed the character of their fossils, and sometimes replaced the calcareous constituent throughout the whole beds; a fact observed by myself in the State of Missouri, where certain oolitic beds of the carboniferous series—and which occur also near Bristol, in England—are entirely converted into siliceous matter. The presence of bituminous matter, too, in some of the fœtid beds of this last series, would give strong support to the opinion that some coal beds may have been the result of outpourings of bituminous matter, and not of vegetable decomposition. The fœtid beds of the western part of the United States are, in some places, so impregnated with bitumen, that when the limestone rocks of the canal were blasted at the falls of the Ohio, the bitumen oozed from the rocks in great quantities, and was gathered for use. I have myself drawn bitumen in considerable and unusual quantities from these rocks.

*In the carboniferous limestones of Tennessee, Kentucky, Indiana, Illinois, and Missouri, I made very rich collections of fossils, many of which are identical with European specimens; indeed, it is probable that most of the European genera will be found there. There are, however, great numbers of species which differ from those found in Europe, some only slightly, whilst others again are quite new. My scientific friend, Dr. Troost, professor of geology at the University of Nashville, and geologist to the State, has discovered some interesting fossils which, it is to be hoped, he will soon find leisure to describe. I saw in his cabinet an asterias, found in the carboniferous limestone, having five rays, but having lost the spines and epidermis. The following are a few of a very long list of European cognate fossils I brought from the States above mentioned: Orthocera, encrinites, producta, spirifers, plagiostoma, natica, ampullaria, delphinula, euomphalus, turbo, pentremites, trilobites, asaphus platycephalus, hamites, terebratula, bellerophon, nautilus, cardia, trochus, turbinoclia, cyathophyllum, astrea, stromatapora, calamopora, manon, eschara, with an innumerable quantity of the zoophytes described in Goldfuss.

In these vast plains, through which the Mississippi passes, extending many hundred miles west, from the Cumberland mountains to the vicinity of the Rocky mountains, we have one continuous floor of carboniferous limestone, and, as far as the geological eye is concerned, it forms one unvarying flat; for, although the superficial level is irregular, that of the calcareous formation, lying beneath the arable soil, appears not to vary much. I had occasion, during my late tour, to examine the coal beds, in various parts of the State of Illinois, which bound the American bottom; a coal measure is opened there for the consumption of the city of St. Louis, distant seven miles and a half. The coal lies in the bluff, which is about 80 feet high, between ledges of limestone, in a perfectly flat seam, measuring about eight feet to the floor. From the stratum of compact limestone superincumbent on the coal, I obtained a fine productus and a terebratula; but in the slaty shale above it, which is loaded with sulphuret of iron, I could not obtain the slightest impression of a plant. It is the same with the coal on the western side of the Mississippi; nor does any part of that extensive carboniferous country present a basin-like appearance, into which trees or plants could have been washed, or in which aquatic plants could have adequately grown; but those who are led by practical observation to assign a subterranean origin to the extensive floors of limestone on which the coal reposes, would also probably indulge the idea that these coal beds may have had a similar origin, fortified as it is by the existence of bituminous matter in the beds of limestone, and by many other considerations.

Extensive as this immense field is, where bituminous coal is found deposited in so many places, yet it by no means represents the geological conditions under which bituminous coal is deposited in other parts of North America. In the granitic trough of Virginia, the coal lies amidst shales and loose sandstones of a micaceous character, the superincumbent shales affording fine specimens of vegetable impressions. In the great bituminous coal measures of western Pennsylvania, separated from these last by the primitive chain of the Alleghany mountains, the coal is found amidst similar but more indurated sandstones and shales, high up in the hills, which have been truncated and furrowed out into valleys, so that the continuity of the veins is found without difficulty in distant isolated hills. But this discrepancy does not point to a different origin, since we know that however different the mineral beds in which the veins of coal lie may be in their constituency, and the heights at which they are found, yet that they are often well ascertained equivalents of each other, and that a difference of level, in deposites of the same period, may be expected where continents have been subject to elevation and depression.

It may also be instructive to observe here that the eastern coal field of the southern States, with which we are acquainted in Virginia and Alabama, may reasonably be inferred, from some known partial indications, to be continuous between those points. In Virginia, it has already become a source of great wealth, giving constant employment to rail-roads and shipping. I can confidently assert, from personal inspection, that there is a very promising line of continuity between those extreme points; and that bituminous coal, of a very fine quality, may reasonably be expected to be found in situations where it does not crop out on the surface. As an evidence of the confidence which may be placed in geological indications, I consider it important to mention, in a brief manner, a coal mining opera-

tion now conducting in England—and which had just been commenced during a visit I paid that country in 1826—upon the sole ground of an entire confidence placed in geological principles, and without any indication whatever of coal cropping out on the surface. A shaft was sunk at Monkwearmouth, near Sunderland, in the county of Durham, through a group of calcareous rocks, which were supposed, from the immutability which rocks are believed to preserve as to the order of superposition to each other, to overlie certain coal veins existing in contiguous parts of the country. The shaft was sunk 344 feet beneath the surface before any coal was found; they then reached a small seam of one and a half inches in thickness. This occurred in 1831, after encountering incredible difficulties in stopping an influx of water that had frequently almost overpowered them. They proceeded to a depth of one thousand feet; when it became necessary to invest more capital in pumps of greater capacity, and this without meeting more coal. But the proprietors had confidence in their operations, and, amidst the loudly expressed doubts of many of their friends, persevered until, at a depth of 1,478 feet below the level of high water mark, they reached a very valuable seam of fine coal, and are actually now carrying their shaft to a depth of one thousand eight hundred feet, in order to reach a vein of coal long worked in other situations, and which they are confident will be found within that depth. This vein, when reached, will repay all the outlay of capital, and become a source of great wealth.

In whatever manner I have been able to regard the carboniferous series of rocks in the United States, however dissimilar the mineral structure of its beds and its levels may occasionally be, yet I have not been able to resist the impression, and could demonstrate, if this were the proper occasion to do so, that the general structure of the series is a fair equivalent of that in Europe, and has probably been produced by the same causes.

The next rocks in the geological series are those which lie immediately above the coal measures, and belong, by common consent, to the secondary. This division includes a very important number of beds which have never been found in the United States; we may possess the equivalents of some of them, such as the muschelkalk of the Germans, and the red lands of Devonshire; further investigations will probably determine that point; but the geological investigations which have been made east of the Mississippi have scarcely left us any ground to expect that any of the members of what is called "the oolite formation," from beneath the purbeck beds to the lias inclusive, will ever be found on this side of that river. It, however, may not be said to be equally true of that group of rocks which lies between the coal measures and the lias. This group, usually characterized by the formation called new red sandstone, has been always considered an important depository of gypsum, as well as the source from whence salt brines have been derived in many parts of the eastern hemisphere. The brines of this country are derived from so many sources, that this group is by no means entitled to be considered their geological depository in the United States. The mineral waters of Saratoga, in the State of New York, and other mineral waters obtained at Albany, in that State, are very strongly impregnated with muriate of soda, containing upwards of sixty parts of that mineral, and these waters rise through the lower slates which repose upon the primitive rocks. The salt wells of Kiskiminetas, in the State of Pennsylvania, are fed from beneath the carboniferous limestone. I have been furnished with borings effected in that part of the country, which have extend-

ed to seven hundred feet, and have passed through important veins of bituminous coal. The floor of the valley where the remarkable salt springs come up, near Abington, in Washington county, Virginia, is transition limestone. The brine is so strong that it only takes five bushels of water to make one bushel, or fifty pounds of salt; great quantities of sulphate of lime come up with the brine. This locality, whether in relation to its valuable deposites of gypsum, the powerful flow of the brine, its unlimited quantity, or the structure of the superficial beds, is more interesting than any one of its class which I have ever seen. I could name other localities resembling these. On the other hand, the salt wells of Selina are fed from a deposite of a marly character, which occasionally has a strong resemblance to some members of the new red sandstone group of Europe. As this great branch of geology has hitherto received very little attention in this country, and awaits investigation, I shall dwell no further upon it at present.

Of the superior portion of the secondary rocks we possess representatives of some very important members, perhaps of all those comprehended in M. De la Beche's cretaceous group, in which the inferior associate beds of the chalk are found. The chalk of commerce I have not yet seen, nor any thing which can be considered its equivalent. Chalk marle, however, and green sand, with adhesive clays, imbedded fossels, (gryphæ) of a lustrous nacre, I have had opportunities of examining in various southern portions of the United States. If the mineral character of these beds, from their occasional dissimilar appearance, could raise any doubts as to their equivalency, the decided character of their fossils would certainly remove them. The agreement of the fossils found in some of the beds in the State of New Jersey with those of the green sand and associate beds in Europe, when considered in connexion with their geological position, can leave no doubt, in the mind of an experienced geologist, of the first being true equivalents of the last; and this fact was announced several years ago.* What makes this conclusion satisfactory is, that the last division of the geological series of rocks, called tertiary, and which, in its natural order, ought to be found reposing on the cretaceous group, is actually found there. The beds of this division approach the top of the geological series, and, coming so near to the present order of nature, we may reasonably expect to find the remains of animal existences, similar in the two hemispheres under similarity of circumstances, and closely allied to existing species. All this has been realized;

*In a country like the United States, where almost every man has an active vocation, and where few have had any leisure to devote to natural history, it is not unreasonable to suppose that the labors of the few have often slumbered in the records of unobtrusive societies, till, like those seeds which require a long inhumation before germination, they evolve themselves, often to become goodly plants, and overshadow the land of science. It often happens, also, that individuals belonging to that class that inconsiderately assigns no importance to the reaction which accompanies disingenuousness, watch the moment, and transplant to their own advantage that which they never planted. I must, even if it is at some expense of what is due to an official document, separate myself from those who set such pernicious examples. The late Cuvier, who was every thing to natural science, has justly denounced such men as guilty of the highest degree of moral wrong. I take great pleasure in declaring that Messrs. Vanuxem and S. G. Morton, of Pennsylvania, two zealous and disinterested cultivators of geology, were the first persons who taught the true geological position of the beds in New Jersey, and their probable extension to the south, where they have eventually been found. I could not say what I have said of these cretaceous and super-cretaceous beds, and observe silence as to the meritorious observations of those gentlemen, without being unjust both to them and myself: for I think any man who would, at this day, attempt to give to a description of them a tone of originality, with a view to overshadow those alone entitled to credit, would justly render himself obnoxious to the charge of having pirated their labors.

we find many shells of this period identical with living shells on our coast at present. In relation to the members of the secondary and tertiary formations of which I have just been speaking, I can assert with satisfaction that I have examined them on the spot, in the States of New Jersey, Maryland, Virginia, South Carolina, Alabama, and Arkansas; besides having seen the characteristic fossils of the first, which were taken from their beds in the State of Tennessee, and from corresponding situations several hundred miles up the westwardly course of Red river, beyond the limits of my late tour.*

I cannot, therefore, but consider the beds I have last enumerated, together with their fossil contents, as establishing a most satisfactory agreement between this portion of the geological series in Europe and America; and when we add to the list the lignites of our country, and the equivalent quadruped a land Saurian remains found in both countries, it may be asserted that there is no important discordance between the marine and fossil remains of their cotemporaneous periods; for time will probably diminish the list of non-equivalents on both sides. Within a very short period, the eurypterus, a remarkable fossil crustaceous animal, discovered some years ago in the United States, and then entirely unknown in Europe, has been discovered there.

It would be inconsistent upon this occasion, with the duty I have now to perform, to enter upon all those details requisite to bear me out completely in what I have advanced of the agreement of the European and American rocks, and which I must defer to more appropriate occasions. That opinion was communicated by me, as far back as the year 1828, to the Geological Society of London. To those who are interested in geological results, without having studied the science, it will be still more satisfactory to know that this constant succession in the order of rocks, in respect of their superposition to each other, is invariable, as much so as that of the order in which the letters of the alphabet stand to each other; so that this result, which it was my intention to show in entering upon this sketch of the principles of geology, will be apparent to them; that the study of the structure of this globe is not that of an inchoate mass, the parts of which were thrown together at random, but that all the parts of the globe which have been geologically examined, have contributed in turns to establish the now generally received truth, that the crust of the earth contains a series of rocks that have come into existence, in regular succession to each other, after a particular and apparent design, and that all the principles of the science, as they are established in one country, can be successfully applied in every other country, for the promotion of human industry and prosperity.

I now proceed to the results of my late tour.

I was well acquainted, by reputation, with the lead deposites in the State of Missouri, though I had not, as it turned out, any accurate idea of the geological structure of the country. It was important for me to examine them, as they were situated amidst the public lands; and the southern part of the State of Missouri being conterminous with the Territory of Arkansas, where my instructions led me, I directed my course to the northern foot of the highlands which extend to the Missouri river, and which lie between

*These fossils were gryphæa convexa, exogyra costata, ostrea falcata, pecten quinquecostatus, cardium, &c. From the deposites in Alabama I have lately collected ammonites, baculites, belemnites, turritella, gryphæa convexa, exogyra costata, and numerous fossils of the cretaceous group, some of which are identical with their European congenera.

it and Red river, with the intention of passing down them from 38° 30' north latitude to their southern slope at 34° north latitude. In passing through the States of Tennessee, Kentucky, and Indiana, I had observed an unusual disposition in numerous beds of carboniferous limestone, (some of which, in the two first states, contain sulphuret of lead, encased in compact sulphate of barytes) to pass into siliceous matter; not only were the fossils, with few exceptions, all converted into flint or chert, but, in some instances, the beds were principally made up of continuous plates of siliceous matter, after the manner of the chalk flint in Europe. I subsequently found this to be very much the case in the State of Missouri, and in the vicinity of Herculaneum, some of the calcareous beds consisted of about two-thirds of their bulk of silex. About thirty-three miles from the city of St. Louis, and about one mile north of the Plattin creek, the Mississippi being very low, I observed an important change in the rocks. A bed of quartzose sandstone, which can only be observed at that stage of the water, and which is covered by a slight rise of the river, jutted out into the Mississippi. For some distance it had a loose granular texture, consisting of quartzose grains held together without cement. In some situations it crumbled between the fingers into sand, but in others it was sufficiently indurated to make a strong rock. The bed runs into the bluff above it, which is a fetid limestone, of a sandy character, and contains sulphate of barytes. This was the first indication I found of an approach to the lead districts. The character of the limestone beds, as they are seen nearer to Herculaneum, is altogether changed here. Instead of compact limestone, with regular seams and blotches of cherty matter, I had suddenly come upon an extensive deposite of siliceous matter, without any lime; and which covered the lower limestone beds, and with calcareous beds superimposed on it, extremely siliceous. In neither of these deposites did I ever find any organic remains. South of these beds the banks of the Mississippi are low, and a valley intervenes, the disappearance of the solid contents of which is rendered less difficult to account for, by the want of tenacity in the rocks. From this point I ascended the country in a direct west course, and soon got upon the extensive open barrens, with their straggling trees, which form the table land of that country, and which are constituted by the calcareo-siliceous fetid beds I had examined on the banks of the Mississippi, and which repose there also on the granular sandstone, as I had frequent occasions of discovering in the ravines and denuded depressions of the country. In one of these slopes, which was well uncovered by a perennial spring of some power, I saw lithographic stone of a very good quality, lying amongst some thin beds of limestone. Pursuing a southwest course, I found the country broken and rolling, the heights principally constituted of sandstone, with limestone uniformly underlying it in the ravines. As I advanced, I found the mineral character of the country less simple, the rocks very much diversified with accidental minerals, and every thing announcing a metalliferous district. I became now desirous of finding some natural sections that would assist in explaining the phenomena around me, but I could find none, and could hear of none, so that it became necessary for me to examine the localities where mining operations were conducted, in order, by an examination of the subterranean arrangement of the metallic beds, to form some estimate of their direction and extension towards those parts of the country where the public lands lay. I accordingly visited the most ancient "diggings" which had been partially carried on ever since the

French had had possession of the country, but I found that the irregular manner in which those diggings had been conducted almost baffled every attempt at systematic investigation. The sulphuret of lead, or "mineral," as it is called in the lead country, has been, in certain localities, at all times found in fragments near the surface of the ground, from the size of a pin's head, in which it can be picked up in great quantities where the rain has washed the soil, to masses weighing several hundred pounds. Sometimes pieces of an intervening size are found, which have been affected by attrition; but, more frequently, the "mineral" preserves its angles very fresh, as it might be expected to do from its brittle cubic structure. Various opinions have been entertained of the cause of so singular a distribution of this mineral substance in loose pieces, and occasionally in such great quantities, near the surface of the earth. The consequence has been, that the whole adjacent country where the mineral has been found, has been excavated into pits, from six to twenty feet deep, so that in the localities of such districts it would be impossible to drive any carriage by daylight, and impracticable to ride securely on horseback by night. This disorder into which the country has been thrown, is entirely owing to ignorance of the geological structure of the country, and the commonest principles of mining, and is much to be regretted, as it will greatly embarrass future efforts, in those localities, at systematic mining. It would be superfluous to enter into any mineralogical detail of those diggings, or to render a very particular account of any of them, since nothing can be more rude than the attempts at collecting ore which they exhibit. In particular localities immense quantities of sulphate of barytes, or "tiff," as it is named, masses of quartz rock, cellular, and occasionally coated with mammillary crystals of great brilliancy, and, in other instances, a profusion of dark red clay, are thrown out of the diggings, together with the mineral.

It was at Mine la Motte I first received satisfactory evidence that the broken up mineral I had seen in the diggings had been occasioned by an accidental derangement of the regular structure of metallic veins, and to which I had always attributed these appearances.

The country around presents an extensive table land, almost denuded of timber, through which a few slight streams run, which are used to wash the soil taken out of the shallow diggings. The whole surface is cut out into pits of various sizes, from four feet diameter to some exceeding twenty feet square, with an equivalent depth. These larger areas have been the result of a discovery gradually made, that the loose fragments near the surface, which were formerly the sole object of the diggings, were connected with *mineral* imbedded in the solid rock. Hence, large areas have been opened, without much relation to method, sometimes to the extent of half an acre, and gunpowder is employed to blast the metalliferous rock; so that mining in this particular district is become precisely what quarrying is everywhere else. The history of these diggings, and the manner in which the sulphuret of lead is often found, is as follows. The streams washing through the superficial gravels sometimes disclose valuable deposites of the ore. Adventurers follow up these indications wherever found, and commence their diggings: when they reach a depth of twelve or fifteen feet, or as soon as it becomes inconvenient to throw out the earth, or hoist out the mineral, a new digging is commenced, and again abandoned for a new excavation. Frequently the superficial soil for about a foot will be red earth, mixed with mammillary quartz, called here "mineral blossom," and petro-siliceous stones; a deposite of red clay of a few feet is then generally found, resting

upon a bed of gravel and flinty pebbles, in which the lumps and fragments, including extremely small pieces of ore, are found. Deposites of this kind do not differ, in any particular of mechanical arrangement, from any gravel deposites I have seen, especially the gravel deposites of gold in the southern States, with which I have been some time conversant, and which are, without exception, the detritus of rocks brought into these superficial beds by aqueous transportation. Beneath these free deposites lies the real metallic formation of the country, consisting of the fetid calcareo-siliceous rock before described, frequently so much decomposed as to admit of being shovelled out, and traversed by horizontal bands of bright galena, or sulphuret of lead, sometimes one inch thick, and frequently a foot thick. In other situations, the ore is very much disseminated in the rock, although always confined in a vein or bandlike breadth, of different dimensions. Where the ore is much disseminated, and the rock is speckled with metallic particles for a great breadth, the ore is usually less productive, yielding about 40 or 50 per cent. of lead, when the compact mineral in other situations yields 65 per cent. Upon such occasions it appears to contain an excess of sulphur. In some instances, I observed broad veins with a considerable dip, but generally the bands of ore were nearly horizontal. This locality appears to furnish a full explanation of the singular manner in which the ore and the sulphate of barytes, in which it is often sheathed, have come into that free and broken situation in which they are found in the superficial deposites. I observed veins at the top of the metalliferous formation, and beneath the superficial deposites, in quarries fifty feet across, and twenty feet deep, containing fragments of ore of various sizes, bright and sharp, with the vein, as well as that part of the rock through which it passed, much shattered and dislocated, the back of the vein being broken in numerous places, and the contents exhibiting strong marks of sudden violence. Sometimes the galena was rent into shivers, sometimes its horizontal sheet was broken up, and parts of the bright ore left standing on their edges, some in one direction, some in another, and the remainder left flat in its old place. In some places the phenomena resemble those presented in the chalk cliffs near the Isle of Wight, in England, where the beds are upset, and the seams and nodules of flint shivered. This is not the case, however, with all the veins. In various quarries of Mine la Motte, especially those which go by the name of Mine la Prairie, where more than half an acre of ground has been uncovered to a depth of twenty feet, the sulphuret of lead is not only seen running horizontally in hard compact veins in the calcareo-siliceous rock, but is sometimes disseminated for a great extent, in specks through the rock, affording to the eye sufficient proof that the stony and metallic matter was deposited at the same time; for, abstract either of them, and no principle of adhesion would be left for the remaining mineral: occasionally the rock changes its character, becoming either calcareous or siliceous altogether, and indeed the structure differs so much as to be sometimes hard, sometimes soft, sometimes granular, sometimes compact. Sometimes a bed of sandstone, three feet thick, will lie upon a seam of bright mineral six inches or a foot thick, though more generally it is much thinner, and lies in a flat plate. I have, however, seen it in veins of two feet thick. The deepest digging or quarrying I observed at this place did not exceed twenty-five feet; they had not yet begun a regular system of sinking shafts and cutting out drifts, but no doubt this will soon be done, as both the public and private lands around the whole region of Mine la Motte are, in my estimation, un-

derlaid by rich veins of galena, that descend very deep towards the central parts of the earth. The superficial indications of this mineral are unerring.

On the approach to a mineral district, numerous localities present a confused but distinct and rather unvarying character of crystallization. Imperfect nodules of siliceous matter, masses of mammillary quartz, the crystals of which are often superinduced upon chalcedonized concentric layers with an agate structure, indications of sulphate of barytes, with small fragments of sulphuret of lead in the rain furrows, betray the metalliferous rocks: these are the situations which are chosen to commence new diggings in, and with invariable success as far as respects the finding ore. But from some works which have been recently constructed, and which I had an excellent opportunity of examining, I am confident a thorough reform in the whole system of mining in that interesting country is about to take place, and that it will henceforward be conducted upon acknowledged principles, consistent with the true nature of metalliferous veins, and that economical administration of the mines which will enable them to contribute powerfully to the national resources.

These works, which, when I visited them, belonged to Messrs. Taplit and Perry, are distant four or five miles from Vallée's mines, and about twenty-five miles from the point where I observed the quartzose sandstone jut out into the Mississippi. They are situated in a small valley at the foot of a ridge of calcareo-siliceous hills, and abound in the external indications I have before described. The proprietors, disregarding the superficial ores, and confiding in the metalliferous nature of the rock formation, had boldly sunk a shaft, in imitation of some practical miners from England, on the other side of the hill, and had been rewarded with the most perfect success. In sinking this shaft, they had come, at random, at a depth of about sixty feet deep, through decomposing calcareo-siliceous rock, upon a vein of sulphuret of lead, and, going down, had reached another horizontal vein upwards of one foot thick, and throwing out from it numerous subordinate veins and threads, into all of which they had cut drifts, wherever the mineral was sufficienty abundant. They had sunk this shaft to a depth of about one hundred and ten feet when I was there, and very obligingly let me down into it, and gave me every aid and facility in examining their works, which enabled me to observe the very curious structure of these metalliferous rocks, and to form a satisfactory opinion of the geological structure of all this remarkable country.

In pursuing the main horizontal vein, I came, in succession, to a great number of cavities or pockets, analogous to those of some parts of the gold region in Virginia, in the calcareo-siliceous rock, of various sizes. Some of these caves, as they are there called, are not more than four or five feet across, whilst others are much more extensive. I examined one which was about forty feet from top to bottom, and about thirty-five feet in diameter. The uniform horizontality of the veins would, in my estimation, have left an extreme obscurity about their origin; but, before I reascended, I had an opportunity of examining what they called the *main channel*, which proved to be an almost vertical vein, filled with compact galena, and about eighteen inches broad. I found the course of this lode to be about N. N. E. and S. S. W. with an inclination of about 18°, and upon examining it further, and reviewing what I had seen before, I had no longer any difficulty in understanding that these horizontal veins, and their subordinate ones, were lateral jets from the main lode, after the manner that Mr. McCulloch has described the structure of the horizontal injections of trap rock into

sandstone at Trotternish, in Scotland.* Having made these observations upon the direction of these veins, I commenced an examination of their structure more in detail, and found they were all what is called in some of the mining districts of England *wet veins*, being, without exception, encased, not in sulphate of barytes, but in pure bright red argillaceous matter, quite wet below, and cutting with a bright waxy face. This red clay accompanies the galena wherever it goes, always including it as in a sheath, and carrying along with it sometimes nodules of quartz, and of iron, zinc, and galena, which last compound is called by the miners *dry bones*. Every one of the pockets or cavities was filled with this red clay, even the large one I mentioned; but at the bottom of each of them was a thick bright plate of sulphuret of lead, that seemed to have sunk to the bottom by its specific gravity. All these circumstances seem to point to a projection of this metallic and mineral matter from below.† At these mines, when circumstances are favorable, they can raise and bring to the surface, as I was informed, 5,000 pounds of the mineral a day—a quantity that could be easily quadrupled if the demand for the metal justified it. This sulphuret yields sixty-five per cent. pure lead of commerce. I had occasion to observe, in numerous instances, that the mineral indications on the public lands were quite as encouraging as at the established mines; but this mineral of lead, to judge from obvious appearances, exists in such inconceivable profusion in the metalliferous region of the south of Missouri and the north of Arkansas, that, like the iron of which I am about to speak, it may be relied on for countless ages as a source of national wealth, and an interminable supply of the most useful metals.

Having completed my examinations of the lead mines, I pursued a southerly course, with the intention of visiting the district of pimitive rocks, as it had been described to me, which lies on about the same parallel with the heads of the Merrimack river. At a considerable distance I perceived very lofty hills of a different aspect from any I had yet crossed, and having an abrupt and stony ascent. The rocks upon the slope of the chain are for a considerable distance denuded, and present a well defined sienite. The chain at a distance appears to run N. E. and S. W., but, upon crossing it, and examining it inside, it deflected into a crateri-form, reminding me, in some of its features, of some ancient volcanoes I had seen. In various portions of this district I found varieties of greenstone, alternating with some horizontal rocks entirely quartzose, and containing no lime. Upon one lofty hill of sienite I found immense breadths of this siliceous rock, extremely and ponderously impregnated with iron; and at a distance of about a mile from this, the iron increasing in quantity in the intermediate distance, I came upon one of the rarest natural metallic spectacles I have ever seen. Upon a mound sparingly covered with trees, I observed a veinlike mass of iron of the micaceous oxide structure, and having a bright metallic fracture, of a steel gray. This vein was about 150 feet above the surface of the adjacent plain, and at the surface had the appearance of being roughly paved with black pebbles of iron, from one to twenty pounds weight: beneath the surface it appeared to be a solid mass. I measured the vein from east to west full 500 feet, and I traced it north and south 1,900 feet, until it was covered with the superficial soil. Unusual as is the magnitude of the super-

*Vide McCulloch's "Western Highlands of Scotland."

†During the eruption off Sicily, in 1832, when the volcanic island was formed, the agitated ocean was filled for several weeks with red mud.

ficial cubic contents of this vein, yet it must be insignificant to the subterranean quantity. This extraordinary phenomenon filled me with admiration. Here was a single locality of iron offering all the resources of Sweden, and of which it was impossible to estimate the value by any other terms than those adequate to all a nation's wants.* Upon a more minute investigation of the country, I found other similar metallic beds, though not of an equal extent, and all upon the public lands.

This sienitic chain comes up through the calcareo-siliceous beds of the country, extends for several miles, and stands separated from all other intrusive rocks, as far as my investigations permitted me to observe: some parts of it are traversed by veins of trap, none which came under my observation exceeding a breadth of two inches. At present, I am disposed to believe that it is an independent mass of intrusive matter, which has been erupted in the most remote periods; and I leave it to future philosophical observers to decide whether it is cotemporaneous with the general formations of the country, and the injection of the metallic veins which I have described. It is highly probable that the shattered veins which have been before spoken of, and their parts left in different positions on their edges, have been rendered so by accidents posterior to their origin. The proximate causes do not require to be looked for at a great distance; the neighboring intrusive masses of sienite announce subterranean operations of great magnitude to have been at some period at work, and we have evidence that the adjacent country is occasionally subjected to volcanic action, perhaps attended with electric power of great extent, from the violent concussions to which it was subjected in 1812, when New Madrid and its vicinity, and the neighboring country to a considerable distance, were so agitated. Upon that occasion, extensive districts were raised and depressed, old lakes were choked up, and new ones formed. New Madrid is not one hundred miles from these shattered veins: the influence of the earthquake of 1812 was felt in their vicinity; and we can easily conceive of an electric force passing through these veins at some other period, and bringing them into the disrupted situation in which we now find them.

As I advanced to the south, the country bore the appearance of being still more pregnant with metallic matter; it became very hilly, the elevations at various points exceeding perhaps two thousand feet from the level of the sea. It was a succession of lofty hills and deep glens, of an arid petro-siliceous character. Nothing was to be seen but nodules of flint and hornstone, masses of mammillary quartz and siliceous gravels, with not unfrequent traces of copper. Quartzose and siliceous matter seemed to have universal dominion; and so incoherent and anomalous were the mineral appearances occasionally, that if I had not traced the formations from the Mississippi, and kept a steady eye upon them, it would have been impossible for me to suspect that I was walking over the equivalents of the carboniferous limestone. Yet this was the fact; for, on descending into some of the deep glens, where there was a prospect of finding the rocks denuded, it often occurred to me to find regularly stratified beds of quartzose sandstone, underlying amorphous masses of petro-siliceous matter, with mammillary quartz, nodules of opaque flint in concentric circles, and compact sulphate of barytes strewed around, with fragments of sulphuret of lead profusely lying about where furrows had been made by the rain. I crossed some lofty hills of massive dark reddish green-

*It yields about 70 per cent. of fine iron, but is found not to weld easily, which I attribute to an excess of sulphur.

stone, lying in a course about southwest from the sienitic chain. On the flanks of some of those hills I found other extensive deposites of micaceous oxide of iron, and frequently oxide of manganese, which the hunters call *black tin*. Zinc also is not uncommonly met with; and nothing is more general, especially in the fluviatile deposites near the streams, than profuse quantities of bog-ore and red oxide of iron. This is especially the case with the deposites of the river St. Francis and its tributaries.

It would be but to repeat these incidents, to detail, in a minute manner, my progress to White river, in the Territory of Arkansas! The country presents a continual change of level, a never-ending succession of hills and valleys. From a remarkable eminence in Wayne, the most southern county in the State of Missouri, I enjoyed a singularly splendid view; numerous lofty ridges were seen running parallel to each other to the north and northwest. That upon which I stood, could not fall far short of three thousand feet from the level of the ocean, was not more than one hundred feet broad, and had a semicircular form, which imparted a crater-like appearance to the deep and gloomy glen beneath. This was as savage as the wildest nature could make it, and possessed a fearful, yet attractive character. The extent and grandeur of the view, the silence and solitude of the scene, were impressive; no birds were present, and it was uninhabited by wild beasts; for the country was of such an arid, siliceous nature, that there was neither water nor herbage, both necessary to the smaller animals, which are the immediate motives that lead the rapacious ones to prowl about.

The summits of these ridges have all the petro-siliceous character before described, and the calcareous beds are very commonly found in the ravines; occasionally, however, some of the regular beds are quartzose, and upon one occasion I found the oolitic beds of the carboniferous limestone, which I had recognised in the Cumberland mountain near Sparta, in Tennessee, and subsequently in Kentucky, *entirely silicified*, with the ovula unimpaired by the change—a fact in geology as important as it is rare, since it shows the influence which siliceous solutions have had at some remote period, not only upon organic remains, but upon the calcareous rocks in which they are imbedded. From the preceding geological circumstances of the parallelism of these ridges, the almost uniform presentation of the calcareous beds in the valleys, and the petro-siliceous beds being superimposed upon them, I am led to class these valleys amongst those which have been called *valleys of denudation*, considering the country to have been at one time continuous as to elevation, and that the valleys have been scooped out by the agency of waters, at some period when the ocean has retreated from this part of the country—an operation to which I have for a long time been led to attribute the peculiar structure of some of the Alleghany ridges.

After leaving the waters of the St. Francis, I had to cross those streams which are tributary to Big Black river—streams of great beauty, all rising in a siliceous country, and so extremely transparent that it is almost impossible to take the fine fish they contain, at their greatest depths, by daylight. These streams all run through alluvial bottoms of various dimensions and of great fertility; but at their confluence with Big Black river, an immense breadth of alluvial soil commences, which extends southeast to the Mississippi, enclosing vast swamps of deciduous cypress, but with these, extensive rich bottoms of land eminently fitted for the culture of cotton and maize, and capable of sustaining a great population. These public lands, which,

for a great extent of country, are subject to inundation from the back water of the large streams, could, as far as the information I received from persons acquainted with their situation is a warrant for my opinion, be in a great measure reclaimed by constructing levées at particular points. At present, owing to their liability to inundation, they are only known to the hunter who frequents the geographical line which separates Missouri from Arkansas, east of Big Black river, where herds of buffalo and elk still roam. Whilst I was in that neighborhood, I repeatedly heard of the buffalo, and saw the hide of a large elk which had been shot out of a herd by a hunter the day before. These are supposed to be the only remains of the buffalo and elk, which have lingered near the Mississippi, in a district where man has not yet permanently occupied the country.

Some of the tributaries of Big Black river, such as the Currant and Eleven Point rivers, which disembogue in the Territory of Arkansas, rise far to the west, in the high petro-siliceous elevations before described. The following fact, as illustrative of the economy of nature, is interesting, and was so constant in its occurrence that at length I came to confide in it as a geological indication. Wherever these streams, towards their heads, had passed over nothing but siliceous minerals, and where calcareous matter was comparatively scarce, I found that those varieties of the fresh water shells belonging to the genus unio, which have of late been considered by some very zealous conchologists as distinct species, were all wanting, except one or two, which conformed in their external appearance to those simple types found in the northern streams of the Atlantic portion of the United States; those, for instance, which are found in the Schuylkill, in Pennsylvania. Whereas, where those streams had penetrated deeply into the hills, amongst the calcareous beds, or had risen almost amongst the calcareous beds at the eastern slopings of the highlands, as the Strawberry river does, I found a very great number of those beautiful varieties which abound in the Cumberland and Ohio rivers, and most of the streams running through the carboniferous limestone of the country east of the Mississippi.*

In descending the southern slopes of these petro-siliceous highlands, I came upon the valley of White river, in Arkansas, which in some places is very broad, and cuts those highlands into two distinct portions. This stream, which is very little known in the Atlantic States, is one of the most important and beautiful rivers in the United States. It takes its rise in the western edge of those petro-siliceous elevations which have received the designation of Ozark mountains, and, receiving several important tributaries, some of which take their rise north of the 37° of north latitude, pursues its course for seven or eight hundred miles of serpentine windings to its mouth, south of the 34° of north latitude, watering that fine agricultural country, amongst the most charming portions of the Territory of Arkansas, which is comprehended in the county of Washington, and, pursuing a general easterly course to its great tributary, Big Black river, near which, having reached the confines of the highlands, it deflects to the south to mingle its waters with the Mississippi. This latter portion of its course lies through the richest alluvial lands, with excellent steam navigation the whole distance from

* I consider this remarkable fact deserving the attention of those philosophical conchologists who distinguish the present period by so much zeal and talent; for certain it is, that to a mind not indoctrinated in the mystery of specie-making, it appears probable that the external arrangement of a testaceous covering, which is so much relied on as a basis for establishing a species in the place of a variety, may be principally due to the presence or absence of calcareous matter.

its mouth to that of Big Black river, and showing an evident practicability of being made navigable still further towards its sources, two hundred miles to the westward. Big Black river itself might be made navigable for a great distance, and without much expense: if the willows and aquatic shrubbery, which impend over its banks in those parts where it is narrow, were only removed, it would be perfectly accessible to steamboats. I have deemed it proper to make these observations, because simple improvements of this kind would lead navigation into the vicinity of those invaluable mineral deposites which I have before described, and which, until something is done of this kind, must remain inactive, together with many other mineral substances both in Arkansas and Missouri, especially marbles and stones of construction.

Having traversed the valley of White river, I again ascended the formations I had been so long upon, and with the same indications wherever I went. Here again I found the horizontal limestone, overlaid by quartzose sandstone and petro-siliceous knolls, but always without organic remains; it would almost seem that the waters, which deposited these beds, were too hot to admit of animal life. Desirous of not overloading this report with geological descriptions, for which a more appropriate place will be found in connexion with the geological sections I shall hereafter prepare, I shall proceed to state that, having crossed Little Red river, one of the tributaries of White river, and the source and direction of which is south of this last, and proceeded some distance south, I perceived a coming change in the geological formations. The sandstone became exceedingly ferruginous, and, from an eminence about forty miles from the Arkansas river, I had a grand view of a perfectly flat wilderness, about ten miles broad, terminated by lofty ridges running east and west. There was not a patch within the horizontal bounds that indicated a settlement; nothing but a dense forest, containing, as I had been informed, and as I afterwards found, no water, except a few putrid pools in the bottoms of the bayous. In this grand picture of the wildest American scenery, there was nothing to break the comprehensive and uniform woody character, but an immense conflagration that was raging in the distance, in my line of advance, and from which rose a dense volume of smoke. Fires of this kind are often occasioned by the inadvertence of hunters, and sometimes purposely to drive game in particular directions. I had often passed through many miles of fired land, where the smoke not only obscured every thing around, but where it was a painful effort to resist the inconvenience it occasioned. On extricating myself from this arid plain, I reached a ridge with an elevation of about 70°, and here I perceived the geological formations were changed; the rocks had become highly inclined; the sandstone had become much intermixed with narrow seams of quartz, which was not compact, but consisted of fibrous bundles of imperfect crystals closely wedged in upon one another. Subsequently, pursuing a southerly direction, I crossed, within a distance of eight miles, four abrupt ridges, running east and west, consisting of highly inclined reddish ferruginous sandstone, intersected by seams of quartz; and, examining the country around with greater diligence, I found that the sandstone rested upon grauwacke slate. I had many opportunities, during the remaining part of my progress to the banks of the Arkansas, to verify this observation, and to satisfy myself that I was upon the true equivalent of the old red sandstone and grauwacke of English geologists. In various situa-

tions I found the old red sandstone formation exceedingly broken up, and the fragments piled up, as it were, in great masses. There are some singular instances of this within three miles of Little Rock, on the north side of the Arkansas river.

The advance to Little Rock, in this direction, is over two miles of alluvial soil, perfectly flat, and the extremely steep bank of the river, during low water, shows on the north side no rocky structure whatever; but on the south side the grauwacke slate crops out very boldly on the bank, and, being the first stony substance met with ascending from the mouth of the Arkansas river, has given its name of Little Rock to the present seat of Government of the Territory of Arkansas.

The grauwacke slate here is highly inclined, and dipping S. E. is traversed by very broad bands of quartz; no red sandstone is superimposed upon it at the river, but at a very limited locality on the bank I found a calcareous deposite containing marine fossil shells belonging to the tertiary beds.* Three miles west from Little Rock, this deposite reappears in considerable quantities, and is quarried for the purpose of making lime. A few miles distant from the seat of Government, the old red sandstone is almost replaced by quartz, especially to the northwest, in the direction of the Great Mammelle river. At a distance of five miles from the town, the ridges of old red sandstone occur again, running about east and west. The Mammelle mountain, distant about 18 miles from Little Rock, is an outlier of the same formation: the southwest aspect of this cone is very imposing, and bears a strong resemblance to a pyramid; on approaching it, the whole façade presented a lofty mural escarpment, about 700 feet above the level of the Arkansas river, according to the computation I was able to make, with a broad talus at the bottom. The southwest edge of this pyramid showed the truncated beds of the rock, standing at an elevation of 75°, and in some places they were vertical. From the summit of this mound there is a surprisingly beautiful view of the surrounding country; wherever the siliceous ridges are, pine timber exclusively prevails, and where the river inundates the low lands, there the deciduous trees betray the inroads it makes. Immense quantities of rich land will be here reclaimed when the system of making levées is introduced. I also visited some isolated high lands on the opposite side of the river; one named Crystal hill had been pointed out as interesting to a mineralogist, and some persons at various periods had pretended to work there upon a silver mine. Crystal hill is a mere outlier of old red sandstone, much inclined, and based upon grauwacke shale and slate. The slate near the river is occasionally very much diversified by strong ferruginous bands, and at very low water shows a good deal of sulphuret of iron. These minerals present appearances which have deceived some sanguine persons, some of whom I met with, urgently desirous of being correctly informed on the subject. After I had completed my examinations of the Territory, and arrived at Little Rock on my return, I thought it a point of duty to warn them against wasting their means in a pursuit, of the probable advantages of which they were not competent judges, and respecting the prosecution of which they were unable to determine where they ought to begin, and where they ought to desist; and I stated to them, what I here repeat, that I had never seen, in any portion of the Territory of Arkansas, the least indication of the precious metals, apart from a small portion of silver contained in the sulphuret of lead. Nor, indeed, did I ever find in the transi-

*Ostrea, turritella, calyptrea, cerithium, &c.

tion rocks of this part of the country, any fossil, except a new species of pentremite in the old red sandstone near the Mammelle.

Having made such examinations in the neighborhood of Little Rock as my opportunities admitted of, I directed my course west, towards the hot springs of the Washita. On leaving the town, I soon got once more upon the old red standstone, reposing on the grauwacke, and indeed never left it, with one exception, until I drew nigh to the Little Missouri river, south of 34° N. latitude. I crossed a small stream, called the Fourche, which runs into the Arkansas, and the heads of other streams said to run into bayou Bartholomew, though I cannot vouch for the accuracy of this last fact, which I had from report. This is a stream that will be of importance hereafter to the settlers in that part of Arkansas, as it is very long, may easily be made navigable, and passes through the fertile county of Chicot, whence it disembogues finally into the Washita river, in the State of Louisiana. Where I crossed these streams,—and I add the Saline river, another important tributary of the Washita, which I crossed twenty-eight miles from Little Rock,—I invariably found, upon a minute investigation of their beds, the same tertiary deposite of marine shells* which I had seen at Little Rock. In the bed of the Saline, I found, at a depth of not more than a foot under the surface, a regular calcareous rock, enclosing immense quantities of oyster shells, the rocky part being evidently formed from the broken down exuviæ of marine animals, disintegrated in long periods of time. The settlers in the neighborhood, whose chimneys were built of mud, which had to be replaced annually, were extremely well pleased with the discovery of a mineral so useful to them for domestic purposes. At thirty-five miles from Little Rock, the country is covered with ferruginous conglomerate of the old red sandstone. Wherever this latter rock is found, the pine† prevails, as is usually the case in siliceous countries; but, about forty-eight miles from Little Rock, I observed an approaching change in the timber, the pine having entirely disappeared, and being replaced by deciduous trees.

Where this change commenced, I found a total change of mineral structure; the old red sandstone had given place to an ancient greenstone, containing great quantities of crystallized hornblende. The rocks rose here about one hundred and fifty feet, and having reached the top, I saw I was upon the brim of what, in the western part of Virginia, near the Clinch mountain, where I have seen several, as well as in the neighborhood of Sequatchee valley, in Tennessee, is called a cove: this cove, which is not quite circular, but rather affecting the form of a gourd, has an interior basin, which slopes pleasingly down, and contains, probably, 1,500 acres of very excellent soil. In various parts of the bottom, I found large masses of decomposing felspar, studded with black tourmalines, some of which were in long prisms, whilst others formed a stellated figure of beautifully delicate circular rays. Some of the felspathic rocks were filled with amorphous masses of white sulphuret of iron, believed by many persons to be silver. In other parts of the cove I found masses of coarse grained sienite, consisting of red felspar, hornblende, mica, and some quartz. But what will always give celebrity to this remarkable locality, now called Magnet cove, is the magnetic iron which abounds there. There is an extensive mound of it covered with pebbles of magnetic iron, from an ounce to four pounds weight.

*Of the Eocene period of Mr. Lyell.
†Pinus Australis, Mich.

From some examinations I made by digging, I am certain these loose pebbles, like those of the vein of iron in Missouri, overlie masses of the metal of prodigious extent. Some of the specimens I obtained, possess a surprising magnetic power; and such is the influence of the mass in place, that Colonel Conway, the surveyor general, informed me he had been unable to survey the country, as the needle will not traverse on approaching this locality. From a careful examination of the different portions of this most interesting cove, I came to the conclusion, that the whole structure of this elevation, as far as its exterior as well as its interior slopes were concerned, was an old greenstone belonging to the intrusive rocks, and occupying, for a limited space, a place amidst the old red sandstone. That, as far as the greenstone extends, all the trees are deciduous, and without its limit all the trees are evergreens and pines. It is impossible to look at this quasi circular brim, and the cove below, and take into consideration, at the same time, all the minerals and metals found there, without being impressed with the opinion that it is the result of a very remote volcanic action, and is, perhaps, one of those extremely ancient craters that have preceded those of which basalt and lava are the products.

The distance from Magnet cove to the hot springs of the Washita is about sixteen miles, keeping always upon the old red sandstone, and no change in the mineral, except one vein of greenstone, with small plates of brown mica, which crops out at about half the distance. At length, nearing a considerable ridge, and turning into a small valley about fifty yards broad, I saw, from the appearance of things, that I had reached the hot springs of the Washita, so great an object of curiosity to men of science, and so little known to the rest of the world.

This valley, which runs about north and south, and divides two lofty ridges of old red sandstone, extends about eight hundred yards, and then deflects to the west. At the foot of the eastern ridge, which is about five hundred feet high, flows a lively stream, which rises in the hills to the northeast: this ridge has, towards the top, a dense growth of pine and oak trees, amongst which are strewed fragments of the rock, often very ferruginous, and pieces of a strong band of iron stone which traverses the ridge in the direction of N. N. E. and S. S. W. and dipping S. E. with the sandstone, at an angle of about 45°. There is, also, some conglomerate on this hill, held together by ferruginous cement. The stream, for a considerable distance, runs upon the grauwacke slate, upon which the sandstone rests. I had entered the valley but a short distance before I saw, on the flank of the east ridge, a rock of a totally different character from that constituting the ridge, impending, like a curtain, down to the stream, and I at once recognised it for a travertino deposited by the mineral waters. This curtain, with some intervals, extends for about four hundred yards from the slope of the ridge, presenting sometimes abrupt escarpments of from fifteen to twenty-five feet, and at other times showing itself in points and coves advancing into and receding from the stream. This travertin extends back east from the stream about one hundred and fifty yards, leaning upon the acclivity of the old red sandstone, to where several powerful springs are now situated. Some of the springs rise in the bed of the stream; one very fine spring rises in its west bank, and numerous others, of which perhaps thirty rather copious ones are found at various heights on the ridge, rising through the old red sandstone rock. Of springs of feebler force there are a great many. Sometimes one

or more of these are said to disappear, and it is certain that new ones are frequently breaking out. Some of them issue from the rock at an elevation of at least one hundred feet from the valley where the present log cabins are built, and where a flourishing village will no doubt exist ere long. A more beautiful and singularly convenient situation for a town cannot be imagined; for, by the aid of the simplest frames to support spouts, the hot water may be conveyed to the houses in great profusion, for baths and medical purposes, as well as for domestic uses. Upon repeated trials with my register thermometers, I found the water of some of the principal springs to be 146° of Fahrenheit, and I never found it higher, although I should not doubt that, during very dry weather, when the mineral springs were not attenuated by the atmospheric waters, they would reach a few degrees higher. But, during my stay, I always found the water hot enough to make my tea without any further boiling, as well as to wash my clothes. Indeed, in this locality, the hot water is so abundant that I found a real trouble in procuring cold water, for the hot springs occupying a breadth equal to four hundred yards of the base of the ridge, all the hot water was discharged into the creek, which in many parts was of a temperature just fitted for a warm bath; and what further assists to keep up the temperature of the spring, is the great number of hot springs rising through the slate at the bottom of the brook. This can be seen at almost a hundred places; and although the water does not scald the hand there, still, upon insinuating my fingers a few inches below the ground at the edge of the stream, I was obliged to retire them instantly, having more than once burnt them in that way. If this stream were turned, it is incredible the quantity of water of a temperature perhaps always equal to 145° Fahrenheit, which might be obtained. During the summer droughts, when the stream is low, no fish are ever seen in it, the water being too hot; but when the season arrives for the cold waters to enter the stream in considerable quantities, then trout, perch, and other fish are taken in all parts of it. I was told, however, that at other portions of the summer, when the whole volume of the stream was not so much heated, the fish would sometimes come up the brook in those parts where no springs came through the slate, but always swam at a particular depth; when crumbs of bread were dropped into them, they rose to them, but stopped when they reached the stratum of hot water, which being rarified, was at the top. Frogs and snakes, when forced in the hot water, or falling in inadvertently, immediately stretch themselves out and die. These mineral hot waters, except one or two of the springs, which are slight chalybeates, are tasteless, having not the least saline trace. A person totally unacquainted with mineralogy, and not aware of any difference between travertino and old red sandstone, might suppose the mineral structure of all the rocks to be homogeneous, and that the waters, not differing in their taste from ordinary warm water, were without any mineral constituent, as the hot waters of the Washita have been reported to be; but these immense deposites of carbonate of lime attest the contrary. On digging about twenty-five feet above the level of the brook, I went through a foot of the carbonate, with traces of sulphate of lime, and then through a dark red oxide, with reniform masses of nodular iron, with botroidal faces. The sulphate was deposited in layers in a circular form. I then came to masses of ferruginous sandstone belonging to the ridge. These seemed to have been loose, and to have been recemented by the deposites from the water, which had filled up all their

interstices. I took out one large mass of iron, the walls of which were, in some places, two and a half inches think, of rich hematite ore, the inside of the nodule containing gypsum and a deep red oxide. These masses almost led me to suppose that they had been deposited by the springs, and that the iron had thus been aggregated by molecular attraction. It is not improbable that the ferruginous matter has been carried to them, during the immense periods of time which have elapsed since these springs first appeared, by atmospheric waters trickling amidst the ferruginous materials of the ridge; the iron certainly appears to be accidentally there. I observed, also, that where these great quantities of the oxide of iron were, it was evident a stream of hot water had passed for a long period of time, and beneath the superincumbent deposite of carbonate of lime, which, as these hot waters have frequently changed their direciion, might very well be. I perceived one considerable underground stream of hot water issuing from a cavity near the bank of the brook, and, upon examining it, found the process going on, iron depositing on the sides, and soft seams of sulphate of lime already established. Under these circumstances, I would not pronounce any of these waters to be natural chalybeates. It is probable that a great many mineral waters acquire some of their properties *in transitu*. I have supposed this to be the case in some sulphuretted springs I have seen, that rise through beds of slate and coal, loaded with sulphuret of iron, much of which may reasonably be thought, at particular depths, to be in a state of decomposition. For the carbonate of lime contained in these hot waters, we may infer a different origin; nor can we consistently assign to the prodigious quantity of caloric which has probably for such immense periods of time raised the temperature of these springs, any source short of those depths from whence the intrusive rocks, the veins of iron, and various other mineral phenomena of the vicinity, have sprung.

These waters rise in a very limpid state, but, as soon as they get into motion, and their parts become exposed to the atmosphere, a mineral deposite commences, attaching itself to dead leaves, to sticks, to any thing that serves for a point of adhesion; upon this deposite a brilliant green, enamelled looking substance presents itself, which increases and thickens, in favorable situations, until it takes the thickness of half an inch. When this can be detached from the calcareous matter it covers, it has a vitreogelatinous appearance, somewhat of the consistency of those glairy substances produced in stagnant water in very hot weather. As long as the water runs over it, it continues to thicken and look green; but when the deposite has dammed up the course of the water, and forms itself another in a distant place, which it is constantly doing, then this green substance, being forsaken by the water, dries up, and crisps up on the surface of the ground, like dead lichens. This dead stuff I examined with a powerful glass, and found that it was a mineral substance of a whitish gray color; on the under side it preserved still a deadish green appearance. In the course of time it undergoes a change, and changes to a deep black calcareous mould, on the surface of which I found, as is frequently done in decomposing travertins, an immense number of individuals of various species of helix.

For many other curious details respecting this mineral substance, which appears to have some affinity with the constituency of some prairies I afterwards visited in the vicinity of Red river, I must refer to those more detailed observations that will more appropriately form part of the labor of some future leisure hours, when some experiments which I have to institute

shall be matured. And in relation to an analysis of the mineral contents of the hot waters of the Washita, it was always my intention to have attempted one, after the best methods my very limited experience in operations of that kind permitted; and I had, on my departure from the Atlantic States, provided myself with such apparatus and reagents as would have enabled me to produce some proximate results; but, upon leaving St. Louis, Missouri, perceiving it was more than doubtful whether I should get my luggage through the mountains, and a speedy opportunity, as I thought, presenting itself, I sent it by water to the mouth of White river, and it had not reached Little Rock when I left that place for the hot springs. I was therefore compelled to content myself with some simple examinations of the waters, and with putting up carefully some bottles of them, in order, on my return, to submit them to the analysis of some distinguished chemists, better entitled to the confidence of those interested in the result than I claim to be; which analysis I hope ere long to be able to state with the authority of the name of the analysts.* That these waters annually perform very admirable cures of chronic complaints incident to southern climates, is well known there: and that their efficacy, and the beauty and salubrity of the country, will soon cause the place to be resorted to from far and near, as soon as proper accommodations for visiters can be prepared, is very obvious. They seem providentially placed there for the use of the inhabitants of the low lands in the vicinity of Red river, and their value deserves to be made extensively known.

About three miles northeast from the hot springs the country is mountainous and broken, consisting of cones and ridges from three hundred to five hundred feet above the streams, which meander in very narrow bottoms. If, in Missouri and the north parts of Arkansas, I had observed the singular propensity to substitute siliceous for calcareous matter, here I found the ferruginous hills of old red sandstone, sometimes consisting of solid masses of flint, at other times of a beautiful novaculite, and again of ferruginous sandstone, with heavy veins of iron passing through them, and imparting a chalybeate character to many springs issuing from their slopes. These hills contain that beautiful mineral substance called the Washita oil stone, which is sometimes well exposed in small vertical layers, and which adhere so tenaciously to each other that, on account of their remarkable brittleness, they are separated with much difficulty. It is not easy, for this reason, to obtain good specimens of it. The curious gradations of this siliceous matter, in the forms of old red sandstone, flint, novaculite, horn stone, and quartzose rock, are surprising. For many miles these lofty hills present a succession of these minerals, in various forms. In some parts rock crystal abounds in great profusion, and of a good transparency and large dimensions: beautiful crystals of quartz of a large size are also found, with double terminations, and not unusually of a bright topaz yellow color. But the most remarkable mineral I saw was the novaculite, or oil stone, a siliceous stone of a pearly semi transparent nature, presenting singularly smooth natural faces, and occasionally tinged, in a very pleasing manner, with metallic solutions. Lofty hills are found there, composed entirely of this material. On one of these I saw several large pits, 20 to 30 feet deep, and as many in diameter, resembling inverted cones, the insides of which were covered with broken chips of this beautiful mineral, some white, some red, some

* The gaseous volume is insignificant, azote and a trace of carbonic acid; the solid contents are carbonate of lime, carbonate of iron, and a trace of sulphate of lime.

carminé, some blue, some quite opalescent. In and near these pits round and long masses were scattered about, of a hard greenstone I had found in place 18 miles distant, and none of them too large for the hand. They were, undoubtedly, Indian tools, and these were the quarries from whence the Indians had formerly obtained the materials they used for their arrow heads, and other weapons of offence. I found no arrow heads there, however; but subsequently on many of the alluvial banks of the streams in the country around, amidst the circular holes and mounds, where their now fallen mud cabins formerly stood, prodigious quantities of chips of the same mineral, and of broken arrow heads also, were strewed around; from whence it may be inferred that they resorted to the mountains for pieces of the mineral, and carried it to their villages to fabricate. Although it is true that no flints have yet been found in the United States, in the chalk formation, yet, in Missouri and Arkansas, inexhaustible quantities of flint are to be obtained, of the best quality, and from the most accessible situations.

During my stay here, I endeavoured in vain to procure a guide to cross the country with me to Cantonment Towson, on Red river, opposite the confines of the Mexican territory; in this direction, except for a short distance, there is not even a bridle path; all roads terminate here, and the passes are only known to the hunters; but heavy rains had set in, and the mountain streams were excessively swollen; the hunters, too, were averse to break off from their favorite pursuit of bear-hunting, which commences at this season. Deeming it imprudent to run the risks to which, under these circumstances, and at so late a period of the year, and without a hunter to provide me with food, I should have been exposed, I reluctantly gave up my intention of further exploring the hills in that direction, and accordingly directed my course to Red river, lower down the Washita.

This river runs upon the grauwacke slate which crops out in various parts of its banks, and it will deserve the attention of future travellers to examine, with great accuracy, the rocks in its vicinity, as I saw indications, which I had neither the time nor the means of effectually pursuing, of the existence of non-bituminous coal, a fact of great importance to the future prosperity of that part of the country. The anticipation, too, is strengthened by those important deposites of anthracite coal, in Pennsylvania and Virginia, being found in the transition formation. On my way I passed between the left bank of the Washita and Magnet cove, leaving it to the northeast, and observed the same difference on this side, between the trees growing on it and the evergreens growing on the adjacent sandstone, which I had remarked on my advance. The route led through a wild romantic country of flinty knobs, and little vales excellently watered. From the Washita to the Caddo river, for about thirty miles, the elevated parts of the country consist of the same siliceous knobs and uplands, some of them approaching to the oil stone of the Washita, and well watered by numerous streams, with limited bottoms of considerable fertility intervening. The *myrica cerifera*, or candle-berry myrtle, was very abundant on these siliceous lands; the deer also were in great numbers, as well as strong gangs of wild turkeys, strutting about in their finest plumage. These birds occasionally take flight with as strong a wing as the wild goose, and light upon the tallest trees. Three miles before I came to the Caddo, the country began to descend towards it, and nature began entirely to change her aspects. On crossing the river I entered upon an extensive level cane brake, in a bottom of great fertility. Here I again

found the tertiary limestone in the bed of the river, and in some adjacent bayous, with the fossils I had before seen at Little Rock. This is a favorite resort of parroquets and ivory-billed woodpeckers. The plants are all deciduous; the old red sandstone, with its pines, is no longer seen, except at very distant intervals, where slight vestiges of it appear. The soil is of an excellent quality, and the bottoms are covered with laurel and holly, which last becomes a tree of considerable magnitude, having a diameter frequently of twelve inches. The almost impenetrable cane brakes, lying five or six miles on each side of the Washita, (into which the Caddo falls near where I crossed it,) and which are of very great breadth in some parts of its course, to join Red river, and to where this last falls into the Mississippi, can never be reclaimed until levées are constructed to preserve the lands from inundation.

Not far from the junction of the Caddo with the Washita there are some salt brines, the natural strength of which it is impossible to measure whilst the soil is so saturated with river water, but eventually, when wells are sunk beneath the beds of the streams, and properly secured, there can be no doubt but that the country will possess salines adequate to its wants. I saw specimens of sulphate of lime, also, which induce me to think that deposites of that mineral may be found ere the wants of the country may require them. As a mineral manure, it would probably be found very valuable when applied to the siliceous soils north of the Caddo, as well as others yet to be mentioned, a little north and northeast of Red river.

From the Caddo to Tournois creek, the distance is about fifteen miles, always upon good level soil. Part of the country, however, was sandy, with heavy beds of a bluish green clay, containing a trace of lime. I found no fossils or impressions in it, but was induced to believe it was the equivalent of some tertiary beds I had seen near Shirley, on James river, Virginia. The whole of this part of the country almost seems to be underlaid with rotten limestone, derived from broken down marine shells. The country hence, for several miles, consists of good bottom land, full of holly and laurel, with occasional hills of old red sandstone of moderate size, with their usual pine trees. Having gone about twenty miles, the country fell again to the south, and I soon came to an important stream which rises to the northwest, and empties into the Washita, called the Little Missouri, from its waters being of a dusky red, muddy color. On crossing this stream I entered upon a dense low bottom of the richest soil, covered with cane,* holly, laurel, and swamp timber, intersected by numerous bayous; this lasted for three miles, when the country began to rise a little again; and, after advancing a few miles, I came upon a singularly black waxy soil of a carbonaceous color, entirely different from any thing I had yet observed, except the surface of the travertino, at the hot springs, which, as I have before observed, was not dissimilar to this, agreeing further in the profusion of helices and other land shells with which it abounded. The country here appeared to consist of a chain of prairies running westward, and parallel with Red river for a very great distance. Some of these prairies were mere bald spots, of half an acre and upwards, surrounded by plants, whilst others were said to contain several hundred acres. In every instance they were surrounded with a belt of timber and plants peculiar to the country. I was informed by Judge Cross, a gentleman well acquainted with the country, and to whose intelli-

* Miegia macrosperma.

gence and hospitality I owe many obligations, that these prairies extend probably many hundred miles to the west, and that it is an opinion deserving of being entertained, that plants are encroaching upon the prairies generally. It was with sincere pleasure I found myself upon geological grounds with which I was well acquainted. The prairies were covered with the fossils, which, as I have before observed, characterize the New Jersey green sand formations,* but the superficial soil was uniformly of a deep black color, resembling charred wood, and in wet weather is of a waxy, plastic consistency, that makes it extremely disagreeable to move amongst. Its fertility is remarkable, and renders it eminently fitted for cotton, which, as I had many opportunities of observing, succeeds well. The black soil, which is substantially calcareous, contains, as I found from slight experiments, a proportion of carbon.

This was one of the most lovely countries I had seen; a gentle rolling surface and fine woods, in which is an abundance of the indigenous crab apple,† with the beautiful bow wood,‡ or bois d'arc, as it is usually called. On examining where the streams had abraded the lower parts of the land, and digging in various places, I found that all these portions of the country which consisted of prairie land, were bottomed upon immense beds of rotten limestone, derived from the testaceous remains of the mollusca I have named, entire shells of which in a soft state are still imbedded in the broken down masses once composed of shells. The zone of black land here does not appear to have a breadth of more than five miles; wherever it is, the same fossils are found, with the undervalves profusely scattered around on the surface. Sometimes the black earth gave place to a deep red marle of great fertility, but in this marle I found no shells, which seemed peculiar to the black prairie land. It was evident I was here upon an ancient floor of the ocean, from which we may infer it had retired with comparative tranquillity, the surface being so little disturbed. The broken down marine shelly matter had accumulated into local beds and extensive hill deposites, after the manner in which we know some existing species accumulate, and the general irregularity of the surface was not dissimilar to that which is presented by the various soundings of marine coasts, where recent surfaces are forming. These accumulations are more or less covered with a vegeto-animal deposite, that, by the constantly acting power of the elements, is partially removed, and carried by rains towards the streams; hence this covering is diminished in some places, and thickened in others. In some situations the black soil is two or three feet deep, whilst in others it is only a few inches thick, in which latter situations the tender roots of plants, having, in extreme dry weather, to contend with a caustic calcareous bed, are liable to perish; the Indian corn, for this reason, is sometimes what is called fired, its leaves drying up and wasting away. These characteristics of the prairie country, as far as this particular zone of prairies is concerned, is common to a vast extent of country to the west of the points I examined. To the east the zone extends from N. lat. 33° 40′ to N. lat. 32° 30′, in the State of Alabama, and can be traced at intervals to N. lat. 40° 30′, in the

*Gryphæa, convexa, exogyra costata, &c.
†Malus coronaria, 20 feet high, 10 inches in diameter.
‡Maclura aurantiaca.

State of New Jersey. Throughout this very extended line, all of which I have personally examined, the characteristic shells of this subcretaceous formation have been found. I possess gryphæa, exogyra, and other shells, from localities far up the False Washita, the neighborhood of the Kiamesha, from Mount Prairie in Arkansas, from Mississippi, from Prairie Bluffs in Alabama, and from New Jersey, all of them identical; and in the subcretaceous deposites of Alabama, I have found the greatest profusion of the fossil equivalents of the genera peculiar to the green sand beds of Europe.* I hope at no distant period to be able to trace, with some precision, the ancient littoral bounds of that geological period, so clearly demarcated by all the unequivocal circumstances I have described.

In relation to those areas which have received the appellation of prairies from their surfaces, denuded of timber, being at certain seasons covered with long grass, I am not of the opinion of those who think that all prairies have originally been produced by firing the timber annually, and thus, by repeated combustions, destroying the timber as well as the sprouts. That much ground has been denuded by such means, I would admit, and the cause certainly would appear a sufficient one for prairie districts, to which no other cause apparently could be assigned. By whatever method plants begin first to germinate in such deposites, it is evident, as I have before stated, that where the vegetable matter is thin, and the season unfavorable, they are liable to perish; and where they would not altogether perish, it must be remembered that this country was stocked, as the more distant prairies still are, with buffaloes, who would, by their periodical occupation of the country in numberless herds, assist in exterminating plants of a vigorless constitution. These may be enumerated amongst the efficient causes of a prairie or meadow state of extensive tracts of country This view of the subject is somewhat strengthened by the observed fact of plants, in modern times, encroaching on the prairies; for I have observed they encroach on the sides where vegetable matter has been washed and accumulated, finding a nutritious bed there, into which they can push their innumerable delicate fibres, secured from the devastating teeth and hoofs of the buffalo, which have now all left this part of the country; for where man settles, that animal never remains long. But there is also another view of the subject.

These vast prairies of the west, as well as the diminutive ones in question, must be admitted to be ancient floors of the ocean. When it abandoned them, they were, of course, without plants; and unless we admit their spontaneous growth, we must suppose them to have germinated from seeds derived from plants growing on lands which had been left with a higher level than the ocean, before it receded from these prairies. Their borders would, of course, be planted first, and thus we can conceive of every new generation of plants giving some of its seeds to the winds and the waters, and gradually extending the forests, like the present members of the human family, advancing upon, and settling the country for the uses of posterity. This seems a more natural and just method of accounting

*Mr. Conrad has personally examined those beds with his usual judgment and industry, and their fossils have been beautifully figured by Mr. Lea, a conchological collector, in his "Contributions to Geology."

for the immense prairies of the west, and the pampas of the southern portion of the South American continent, than conjectural opinions founded on a convenient method adopted by the Indians of securing their game, and which they have practised at all times, certainly with the effect of thinning, but without destroying the timber, as we know from the immense forests of Virginia, Tennessee, Kentucky, Indiana, Missouri, and Arkansas, which were annually fired by the Indians, to burn the high grass, that they might better see their game—a practice which destroyed the undergrowth, but only thinned the trees; and now that the Indians have left these countries, we find the undergrowth rapidly occupying the ground again. Before we receive opinions altogether hypothetical in relation to the cause of the prairie condition of land, it seems as if we were bound to inquire what was their first condition, consistent with the geological fact that they are ancient floors of the ocean. It, therefore, appears to me to be probable that many of these prairies have never, since the ocean left them, been covered by any vegetables of greater importance than the gramina. Under this view of the matter, it is consistent to suppose, what is personally known to me to be the fact in many observed instances, that trees and plants may be transplanted to those prairies with perfect success.

It has appeared proper to me, in drawing up an official report, which has for its object the practical advantages to be derived from geological investigations, to abstain from entering into the consideration of some of those particular branches of geology which impart at this moment so much interest to the scientific literature of Europe; and if I have inclined to the support of an igneous theory for the origin of the rocks in the inferior portion of the geological series, it is because I have been convinced, by a long study of the mineral phenomena connected with the primary rocks of this continent, that there is no other conclusion to which similar phenomena can ever probably lead my judgment; and I have no reason to suppose it is unsafe ground, since the most eminent cultivators of the science in Europe, upon an examination of their own continent, have come to the same opinion. The deliberate opinions of such men, enriched by all the aid that chemistry and other cognate branches of the science are susceptible of, are themselves authority. But I was chiefly led to express the opinions which are found in this report, respecting the supposed expansive power resulting from the igneous forces operating in the radial space, by the expectation that it would lead many ingenious minds, who had not turned their attention to the structure and origin of metallic rocks, to examine some interesting localities through the medium of these opinions, which, as they have never deceived me, would thus, I trusted, be useful to them. In this, as well as in all my investigations, I have been sincerely desirous of making my labors useful, rather than of embellishing them by any deviation from a rigorous examination of facts, upon which all true and useful results appear to depend.

The exigencies of society have reached a stage in Europe, to which we are advancing in this country. There, not only the metals, but every rock, every stone, every bed of sand or clay, has its value. A quarry of stone, of whatever quality, produces an income, and canals and rail-roads are the facilities which carry them cheaply to their destination. A very few years ago, geology, in this country, was merely considered a liberal branch of

knowledge; now, it is universally deemed a science which teaches the true structure of the earth, and the most probable situations in which its metals and minerals are to be found. Before many years elapse, the study of the science will be general here, because the wants of society are enlarging. In the increasing desire manifested in the States to establish geological surveys, we have the evidence of this, and of the existence of a spirit that must lead to a very great development of the mineral resources of the country, as well as the extension of its intellectual character. But, in putting these State enactments into operation, it should never be lost sight of, that the advantages to be derived from investigations, the proper and sole objects of which are physical facts, depend entirely upon the practical experience of the persons to whom they are to be entrusted.

Geology possesses two classes of students, the conchological and mineralogical. The first, which is the most numerous, is principally engaged in collecting evidences from the rocks containing organic remains of a former state of things, whence to deduce arguments to show the true causes which have governed the present disposition of the stratified masses of the crust of the earth. The writers of this class are amongst the most eminent men in Europe; men who are well acquainted with the inorganic rocks, and who, by their genius and untiring zeal, have made a deep impression upon the present age. The voluminous literature of which they are the parents, has found an immense number of admirers amongst men of varied attainments, most of whom, though well acquainted with geological literature, have not had practical opportunities of examining nature extensively, and reconciling the complicated and irregular manner in which, perhaps, the same operation is effected, in distant localities.

The second class is composed of men who, keeping up with the knowledge of the other branches, have devoted themselves rather to a practical study of that portion of the geological series which comprehends the metalliferous rocks, and the other productive branches. In England, the demand for useful information from this class is so great, that the profession of *mineral surveyor* has grown out of it, one entirely unknown at present in this country.* In estimating the value of an estate there, the capacity of the agricultural surface is not alone considered, but a great importance is given to the probable perpendicular value of every acre, as it can be computed upon geological principles. The value of an estate to an individual depending very much upon these circumstances, men of long experience and approved judgment are alone confided in. If this, as it must be seen to be, is of so much consequence to individuals, of what immense importance is it not to the State Governments, in putting their enactments into operation, to select individuals of the greatest experience? For how is that complex appearance of rocks in different parts of the same country, which, though altogether different in their external characters, may be true equivalents of each other, to be reconciled by men who have only studied them in books? or how can men claim to have their opinions confided in respecting the tendency, direction, and quality of metalliferous veins, upon which

* Mr. William Smith, who has received the first Woolaston gold medal from the Geological Society of London, was a mineral surveyor, and the author of the first geological map of England.

the outlay of great capitals depends, who have never been down in a mine, and have studied minerals only from cabinet specimens? In geology no learning can supply the place of experience. A geologist may be an indifferent analyst, and no man is presumed to be a geologist because he is a learned chemist or a profound mathemetician. Such an important trust, therefore, as is comprehended in the geological survey of a State, should be confided only to men of long approved experience.

I have thought these observations not out of place, because, in the incipient encouragement now given to geology by some of the State Governments, and which will probably be done by all of them, it is important that the few individuals in the country who have the requisite experience, should not be overlooked in favor of others, who are perhaps not aware themselves of the extent of practical experience required to make any man's labors valuable, and worthy of being transferred to geological maps of the countries they survey. It must be evident that a geological map of any country, upon which all the important mineral and metallic deposites should be accurately laid down, with their direction, extent, and other important incidents belonging to them, would be of great value. How much, then, does it concern the interests of the United States, that rational estimates of the national resources, with all those infallible indications which should precede internal improvements, and whatever else appertains to a monument of such singular importance to them as a general geological map would be, should be done with the utmost accuracy. It seems called for both by the best interests and the reputation of the country.

Before I close this descriptive portion of my report, I shall ask to present a few remarks on the Arkansas and Red rivers, which I trust will be found somewhat interesting. Both these streams are remarkable for their tortuous and serpentine course, and for the important deflections from their courses, which can be sometimes traced. The history of Red river illustrates well movements of this latter class. From the point where it turns to the east, a little north of 31° north latitude, it appears to have once flowed in a south direction down the line of the Atchafalaya, into the bay bearing that name in the Gulf of Mexico. There is a chain of lagoons on that line still rafted up with timber, and no doubt, when a head was formed capable of resisting the current, it gave the river its present easterly direction into the Mississippi. In those remote periods, when the False Washita and the other tributaries of Red river were working out its channel, the deposites of timber must have been immense, not only filling its channel to the Gulf of Mexico, as I have supposed, but rafting up its present channel as low down as its present mouth in the Mississippi. The remains of those ancient rafts are still to be seen, near its mouth, adhering to its banks, the main body having rotted away, and passed down with the current, to the point where the operations commenced of clearing out the present raft. But even now, such is the abrasion produced by the river, that the annual accumulation of timber at the head of the great raft is very great, and the conseqent inundations from back water very injurious. When the great work of cutting the raft out is accomplished, an immense quantity of rich lands will be brought to their true value, and the salubrity of the country much improved.

These chains of lagoons are found both on the north and south sides of Red river, and are amongst the immediate causes of the insalubrity of the climate during certain months. The past summer was intensely hot and dry, and one of these large lagoons, near Lost prairie, on the Mexican side of Red river, a beautiful tract of land over which I passed, had experienced so much evaporation that it could not preserve its fish; the water became glairy, and incapable of sustaining them, and they were floating dead on the surface. The course of the Arkansas is, in like manner, subject to constant changes, as a small circumstance will lead to the deflection of this noble, but too uncertain stream. The lodgment of a tree will be the commencement of a bar that will throw the current to the other side, which, beating against a low and weak part of the opposite alluvial bank, will, in a short time, if the bank happens to form a reach there, wear its way through, leaving an island and a chain of lagoons in its old bed. In the vicinity of the Mammelle mountain is an immense swamp, through part of which I passed, and which contains, perhaps, thirty thousand acres. The timber on each side, being much killed by the water, stands dead in innumerable lofty bare masts, forming a picture of perfect desolation. The cypress,* the cotton-wood poplar,† and the *populus monilifera*, the blackberry,‡ the triple-thorned acacia,§ and many other trees, attain an immense size here. The lagoons in this swamp extend for several miles where the old bed of the river was; wild geese, ducks, and other aquatic birds, are here in incredible numbers, as well as swans occasionally. Nothing can be more singular than the aspect of the trees in this wild place. Their trunks appear to be painted red for about fifteen feet from the ground; at that height a perfectly level red line extends through the whole forest, marking the rise of the waters at the last great inundation, which occurred in June, 1833, when the Arkansas rose thirty feet. Millions of acres of rich bottom land of these countries are thus rendered useless, and can never be brought to their intrinsic value but by levées, constructed at particular points, to keep out the waters from the direct course of the river, and the back waters of the bayous that empty into the river. Until measures of this kind are taken, these districts will be a nuisance to the settlers, both in respect to their insalubrity, and their being the resort of the numerous gangs of wolves which infest the country. I spent one night in the swamp alluded to, that of the 22d of November last. The thermometer had fallen to 24° Fahrenheit, and strong ice was making. The noise made by the incessant howling and yelling of these animals exceeded any thing I had ever heard; some barking in one tone, some screaming in another, as if each was suffering bodily pain. This uproar is generally loudest just before the approach of day, and appears intended as a signal for stragglers to come into the wilderness, where they usually crouch during the day.

From this point of the river down to its mouth, a distance of about 300 miles, a fine opportunity presents itself of studying, not only the structure of this vast body of rich alluvial land, but of the action of the river, and I passed a week in following it up to its junction with the Mississippi, landing and examining the country at many interesting points. The whole line presents a succession of reaches, sand bars, and mutations, produced in the

* Cupressa disticha.
† Populus angulata.
‡ Celtis integrifolio.
§ Acacia triacanthos.

manner I have before mentioned, and the serpentine course thus established doubles the distance. Its general course to the Mississippi is southeast, but it is constantly, every five or six miles, describing curves, and following the direction of southwest and northeast. The channel is thus alternately on the right and left bank of the river. Sometimes an extensive sandy beach will project itself from the opposite shore, and jut so far into the channel as to render it very difficult to get over* with a boat drawing three feet. These beaches sometimes cover more than fifty acres of land, and are thrown up by the stream as it abrades the banks at the foot at which it runs. The banks being thus constantly undermined by the action of the river, immense masses of timber, and the lofty canes,† twenty to twenty-five feet high, that grow up with it, fall into the river with the earth about their roots, and thus both form the snags and sawyers which embarrass the stream, and a point of resistance which gives a new direction to it. Sometimes, during the great freshets which descend from the upper country, the river not only breaks through the reaches of land which jut out into the river, but absolutely gets under the extensive sand beaches, and, lifting them up above the general level of the country, deposites them upon it. In this way, I have observed considerable portions of rich plantations, distant several hundred yards from the edge of the river, buried several feet deep beneath a barren sand. At other times, the freshets plough the whole of the vegetation up from the ground for thirty or forty acres, and deposite it in a mass, with all its timber, upon some beach lower down.‡ This is the general character of the Arkansas as I have observed it for several hundred miles. and I have been told by those who have visited it nearer to its sources, that it has, in some places, abraded the whole surface of the country for ten miles in width.

These abrasions are more interesting to the geologist than to the planter, for the fresh fracture enables him to trace for great distances the party-colored deposites, alternating with each other, some white, some red, some gray, and often intermixed. Some parts of the banks are from 100 to 130 feet high, and assume an important appearance in a country where the surrounding land is much of it a low dead level. About 50 miles from Little Rock the Red Pine bluffs occur, which the river is fast wearing down. Twenty miles lower down are similar bluffs of a lighter color, called the White bluffs, and about thirty miles lower down are the Pine bluffs, which are higher than the others. At the Red Pine bluffs there is a bed of limestone, seen at low water, formed of broken down oyster shells, like those in the Saline river. This is the only calcareous deposite within my knowledge in the banks of the Arkansas east of Little Rock, except one I afterwards saw in the high banks at the post of Arkansas. This river presents a fine study of fluviatile deposites, not only in the party-colored seams of the old banks, but where they are at present forming on the surface of the country. The inundations within the last ten years have made similar

* Some conception may be formed of the difficulties which first settlers have to contend with in these frontier settlements, by stating that a very respectable inhabitant, who resides about 50 miles west of Little Rock, absolutely rode on horseback, with his bride, to visit some friends, up the bed of the Arkansas river 200 miles, fording the river from sand bar to sand bar.

† Miegia macrosperma.

‡ There is a fine instance of this at Mons. Barraque's, about 140 miles from Little Rock.

superficial deposites; sometimes a layer of red clay, sometimes of white sand, sometimes a mixture of both, and occasionally large blotches or masses of whitish clay, are enclosed in a regular deposite of red clay. Appearances of this kind are familiar to geologists in some indurated rocks, but have not been accounted for as satisfactorily as we can account for the deposites I have been speaking of in the banks of the Arkansas.

This immense river has its sources six or seven hundred miles apart. Its southernmost branch, the south fork of the Canadian, receives streams which rise near the 34° of north latitude; its most northerly source is from the Rocky mountains, between 39° and 40°; and its most eastern sources, or the heads of the Illinois, rise about 38° north latitude, at least six hundred miles from the central and principal sources in the Rocky mountains. The southernmost sources flow through an ancient deposite of red argillaceous matter for several hundred miles, and it is this which colors the Canadian and its branches. To the north the western sources bring down mineral matter of different colors, but to the east the sources take their rise in a high siliceous country, and their mineral deposites are indicative of their origin. The branches of the Arkansas, included in this area, are numerous; the Illinois, the Neosho, the Verdigris, the Canadian and its two principal tributaries, are all fine rivers, and would belong to the class of most important European streams. They are of unequal length, and, being separated by great geographical distances, are subject to increase their volume at distinct periods; and this volume, on account of their unequal length, being emptied at distinct times into the main channel of the Arkansas, the deposites which this last leaves, in its irregular progress to the Mississippi, are characteristic of the mineral substances which its tributaries and their branches pass through. The Canadian, which passes through a red earth, has always dull red waters, like those of Red river, rising still further south. We are hence enabled to assign the red deposites to the materials transported by that stream, whilst the whiter and siliceous deposites may be attributed to the eastern tributaries. Those who have had opportunities of observing the eccentric movements of floods of this class, soon learn to distinguish what circumstances, whether arising from partial eddies, owing to the change of level produced in periods of inundation, or from ordinary mechanical causes, have produced both the regularity and irregularity of deposites; and how it is that blotches of mineral matter, both large and small, are found enclosed in deposites of a homogeneous character, differing from them, just as the whiter matter of the eastern branches of the Arkansas, brought down by the Illinois, is found enclosed in the extensive beds deposited from the waters of the Canadian. It is in the study of phenomena of this character, where fluviatile deposites are effected upon so immense a scale, that perhaps an explanation of many difficult presentations of mineral matter, observed in older indurated rocks, may be suggested. Upon the edges of these ancient beds of the river are mounds and Indian tumuli, with trees occasionally growing on them, some of them five hundred years old; quantities of the Indian arrow heads are strewed around, and some are buried several feet beneath the deposites—facts which show that this alluvial country, possessed by a few bands of the Quapaws when the whites first settled in it, has been, in very distant periods, inhabited by the aborigines.

Amongst the most interesting results of my late tour, I must enumerate, first:

The establishment of the fact, from personal observation, of there being, in the State of Missouri and the Territory of Arkansas, an amount of the ores of lead and iron, of an excellent quality, not only more than adequate to any estimate of the domestic consumption of this nation, but such as may justify the expectation that it will form an important element hereafter of commercial exportation from that part of the world. When it is considered that the sulphuret of lead forms, as described in this report, such an important portion of the solid rock, at one point; and that it exists, in an equally profuse manner, perhaps, through various points for a distance of five or six hundred miles,* this language will not be deemed extravagant.

But looking forward to the future prospects of these regions in the mining branches of industry, who, that has had but a glimpse of those fertile alluvial territories to the south, penetrated by so many thousands of miles of river navigation, where fifty millions—and a much greater number might be asserted—of North Americans have yet to establish themselves; where the amount produced of sugar and cotton, which excites the admiration of our own day, will be referred to as the mere germ of production hereafter; where, when populous cities, increased shipping, and well protected plantations, shall have placed these imperfectly known regions in the same class with the most powerful portions of the earth; who can doubt but that a part of the immense wealth thus accumulated will be invested in working the inexhaustible mines which lay, as it were, at the very door of New Orleans, a city evidently destined to rank hereafter amongst the first in the world? If one nation can ever permanently undersell the others in those metals, it must be one possessing mines from whence they can be extracted with equal facility as from those in question, and exported with so little charge.

I consider it also as a result of great importance, that the extensive investigations which I have so recently made, have gone, without exception, to strengthen the opinion I submitted to the Geological Society of London in 1828, as to the series of rocks in the United States being the natural equivalent of that observed in Europe, from whence we may infer that the causes which operated to bring the rocks there into the particular order of superposition they preserve, have operated here, and probably have acted upon the whole crust of the earth. It is true we have not yet found that remarkable portion called the oolitic formation, lying above the coal measures, but this is only a part of the series, and in every country where geology has hitherto been practically studied, some part or other of the series is wanting. At many points of our Atlantic coast, including the city of Washington, there is no rock intervening between the superficial detritus and the gneiss, which is the lowest rock but one of the whole series. Localities, with imperfect arrangements of this nature, are like a harp, where, though some of the party-colored chords are wanting, yet the rest are there, and preserve their unchangeable superposition to each other. This correspondence of structure will result in making the principles of the science of geology, like those of geometry, applicable every where.

It is a remarkable circumstance, as I had occasion to announce in 1828,

* North to the Ouisconsin country.

that, with the exception of the tertiary and subcretaceous beds of the coast, nothing more recent than the coal-bearing series had been found in the United States. A fact so unusual in a continent of such great extent as North America, can hardly be attributed to denuding causes, and would rather lead us to the inference that this part of the globe has in fact emerged from the ocean before the continent of Europe did, and that, geologically speaking, in reference to the history of the earth, this has very strong claims to be called the *old world*. If no denuding causes adequate to the phenomenon have been in action, we must either adopt that opinion, or suppose that, whilst other parts of the subaqueous world were receiving sedimentary deposites, the waters of the ocean, which covered the vast area devoid of the entire oolitic system, were situated so as not to receive any sedimentary materials. The opinions I communicated in 1828 have been confirmed by my late tour, and strengthen the conclusion to which my judgment has been for some time coming, that this continent is much older than the European continent.

It will be felt, also, as an interesting step in the progress of geological knowledge, that we shall be enabled hereafter to trace, with accuracy, the littoral line so clearly made out by the subcretaceous fossils of the same genera which have now been continuously found for near two thousand geographical miles. It is evident that the ocean retired cotemporaneously from this line, either from the deepening of its bed, produced by distant causes, or from the elevation of the land; and this is the geological period which may be fixed for the commencement of those great deltas of rich aliuvial matter brought down by the rivers alluded to in this report, and which are hereafter to form so important a portion of the civilized earth.

It remains for me only to state that I have made ample collections of minerals and geological specimens of the countries I have visited, all of which, when they reach this city, will be placed at the disposition of the Government.

It was altogether impossible for me to prepare the geological sections I should have wished to accompany this report with. The short time which has elapsed since my return has barely sufficed to draw it up: it would have given me great pleasure to have made it more perfect; but as both Houses of Congress have called for it, I hasten to submit it.

Very respectfully,

G. W. FEATHERSTONHAUGH,

U. S. Geologist.